THE PHILIPPINE
JOURNAL OF SCIENCE

VOL. 93 SEPTEMBER, 1964 No. 3

# THE ANTIBIOTIC ACTIVITIES OF SOME PHILIPPINE LICHENS

By PATROCINIO SEVILLA SANTOS, BETTY S. LAT and MACARIO A. PALO

*National Institute of Science and Technology, Manila*

(Received for publication, February 30, 1964.)

THREE PLATES

Lichens which are known to botanists to consist of part algæ and part fungi have been extensively studied by several investigators as sources of antibiotics. Pratt, et al.(13, 14) have shown that the unicellular green alga, belonging to genus *Chlorella,* is the source of an antibiotic known as chlorellin, and that the extracts of several species of marine algæ inhibited the growth *in vitro* of one or more of the following bacteria: *Staphylococcus aureus* (=*Micrococcus pyogenes* var. *aureus*), *Escherichia coli,* and *Pseudomonas æruginosa.* In their studies on the antimicrobial activity of 150 kinds of marine algæ from Puerto Rico, Burkholder, et al.(6) observed that 44 per cent were active against S. *aureus* and that the two species *Dictyopteris plagiogramma* and *Goniaulax tamarensis* which were usually found associated with the red tide water possessed both inhibitory and growth-promoting properties. Likewise several fungi, notably *Penicillium chrysogenum-notatum, Aspergillus fumigatus, Aspergillus flavus, Aspergillus clavatus, Penicillium claviforme, Penicillium patulum, Penicillium citrinum,* etc., have been shown to yield antibiotics.(17)

There are also several reports about the antimicrobial activities of lichens and their chemical constituents. For instance, Stoll, et al.(18, 19) in a survey of antibiotics from lichens in Switzerland in 1947 found that out of the 58 species that they examined, 38 produced a distinct antibacterial action *in vitro*



STI-13-0987

against *Staphylococcus aureus*. They also reported that usnic acid which is present in a large number of species had an inhibitory effect upon *S. aureus* and mycobacteria.

Burkholder, et al,(4) showed that out of 42 species of lichens examined by them, 27 inhibited *S. aureus* or *B. subtilis*, four inhibited *Proteus vulgaris* or *Alcaligenes fæcalis*, but no antagonistic action on *Escherichia coli* was shown. Burkholder and Evans(5) in their studies of 100 lichens collected mostly in Connecticut, Massachussetts, and New Hampshire, observed 52 to inhibit either *B. subtilis* or *S. aureus* or both. They also noticed that although the gram-positive bacteria including several pathogenic types were inhibited, the gram-negative forms with a few exceptions were resistant to their inhibitory action. Thirty-five species of *Cladonia* have been found active against either *B. subtilis* or *S. aureus* or both of these bacteria. Usnic acid was shown to be present in 17 active species. This compound was demonstrated to be active against *B. subtilis*, but not against *S. aureus* or *E. coli*.

Litvinov and Rassadina(11) who investigated the antibiotic properties of lichens from the USSR found that the organic-solvent extracts from 32 samples possessed high antibacterial activity against *S. aureus*, that eight samples exhibited weak activity and that 11 were not inhibitory at all to this test organism. Extracts from two lichens had pronounced activity against *E. coli*, while five samples exhibited weak inhibitory power.

Asahina and his associates among whom was Kutami,(1) in their series of investigations of the chemical constituents of lichens in Japan, established the presence of lichen acids in several species.

Seshadri(16) conducted a chemical investigation of Indian lichens and isolated compounds belonging to the fatty acid, depside, depsidone, pulvinic acid, anthraquinone, phenanthrenequinone, xanthone and diphenylene oxide groups. Other investigators, such as Dahl(7) and Hale(8) who also isolated some of these types of compounds, used them in lichen systematics for distinguishing chemical strains.

The chemical components of lichens have been examined for their antibiotic properties by Stoll, et al.,(19) Burkholder and Evans,(5) Borkowski, et al.(3) and Liu, et al.,(12) who reported that the lichen substances were more or less active against the gram-positive bacteria and mycobacteria, but were inactive against the gram-negative forms.

Of the early works on Philippine lichens, those of Wainio (20, 21, 22, 23) and Herre(9) made no mention of their curative properties. Quisumbing(15) refers to a lichen, *Usnea philippina* Wainio, found growing on the bark of coconut trees that is used as a stomachic, but does not mention the antibiotic activity of its extract or its chemical constituents.

This preliminary investigation of Philippine lichens has been undertaken to gather information regarding their potentialities as sources of antibiotics, and is in line with similar studies abroad where foreign species have been reported to possess antibiotic properties.

## MATERIALS AND METHODS

The lichens used in this investigation were collected from barks of trees, from soils, and from rocks and stone walls in various places such as Quezon and Baguio cities, Cavite, Rizal and Batangas provinces, and Mt. Mayon, Albay Province, (Plates 1 and 2.)

The antibiotic activity of the lichens was determined, following the method of Stoll, et al.(18) as follows: 100 mg lichen powder was suspended and boiled once in a solution consisting of 0.8 ml of 5 per cent dextrose and 0.2 ml of 0.1 N NaOH. Of the lichen broth, 0.2 ml was dropped to one of the perforated (punch) plates (perforation diameter 13 mm) seeded with the test organisms; namely, *Micrococcus pyogenes aureus* 209 P, *Micrococcus pyogenes aureus* (penicillin resistant), *Bacillus subtilis* FDA 219, *Escherichia coli, Alcaligenes fæcalis, Salmonella gallinarum, Pseudomonas aeruginosa, Mycobacterium tuberculosis* 607, *Saccharomyces cerevisiæ, Candida albicans, Fusarium moniliforme* and *Ceratostomella paradoxa.* After incubation for 24 hours at room temperature the zones of inhibition around the perforations were measured. Plates seeded with *C. paradoxa* and *M. tuberculosis* 607 were incubated, respectively, at room temperature and at 37°C for 48 hours.

Experiments were further performed to determine whether the active compounds could be extracted with some organic solvents such as acetone, benzene, butanol, ethanol, ether, methanol, and petroleum ether and NaOH-dextrose solution. In these experiments seven selected active species of lichens *Crocynia membranacea* ARL–22, *Stereocaulon* sp. ARL-1B, *Ramalina farinacea* ARL–62, *Parmelia dactylifera* ARL–75, *Physcia albicans* ARL–33, *Lecanora subfusca* ARL–47 and *Usnea* sp.

ARL—63 were used. The powdered lichen material (500 mg) was ground in a mortar with 10 ml of each solvent. The organic extract was filtered and the filtrate evaporated with the aid of an electric fan. The residue was treated with a 5-ml solution of dextrose and NaOH similar in composition as that used for extracting the antibiotic from the powdered lichen. The antibiotic activity of the extract was determined following the method of Stoll, et al.(18)

## RESULTS AND DISCUSSIONS

As shown in Table 1, out of the 38 lichens obtained from 33 species, 30 extracts from samples belonging to 26 species were found active against at least one of the 12 test microorganisms used. Twenty-six extracts from 24 species or 68.4 per cent of the 38 samples tested were active against at least one of the gram-positive bacteria *M. pyogenes* var. *aureus* 209 P, *M. pyogenes* var. *aureus* (penicillin resistant), and *B. subtilis* FDA 219. These lichens are *Crocynia membranacea* ARL–22 and ARL–43, *Cladonia* sp. ARL–27, an unidentified species of lichen family Graphidaceæ ARL–89, *Lecanora subfusca* ARL–47, *Lecanora* sp. ARL–69, *Lecanora varia* ARL–97, *Lepraria chlorina* ARL–34, *Pannaria mariana* ARL–28, *Parmelia dactylifera* ARL–75, *Parmelia zollingeri* ARL–93, *Pertusaria* sp. ARL–79, *Physcia albicans* ARL–3 and ARL–33, *Physcia picta* ARL–60, *Physcia* sp. ARL–45 and ARL–102, *Pyxine* sp. ARL–50 and ARL–95, *Ramalina farinacea* ARL–62, *Ramalina* sp. ARL–18, ARL–29 and ARL–64, *Stereocaulon* sp. ARL–1B and ARL–25, and *Usnea* sp. ARL–63. These findings which apparently show the greater antagonistic propensity of the lichen extracts for *M. pyogenes* var. *aureus* and *B. subtilis*, conform with those obtained by Burkholder, et al.(4)

*Parmelia zollingeri* ARL–93, *Ramalina* sp. ARL–18 and ARL–64 were the only extracts found active against *E. coli*. This finding differs from Burkholder, et al's observation(4) that not even one of the 42 lichens they tested showed any activity against this gram-negative test bacterium. None of our extracts inhibited *A. fæcalis*, while Burkholder, et al.(4) reported two species, *Cladonia glauca* and *Parmelia conspersa*, to cause slight inhibition of this test bacterium. Fourteen or 36.8 per cent of the 38 extracts from 13 species inhibited *Mycobacterium tuberculosis* 607 as well as the gram-positive test bacteria. These active extracts came from 13 species; namely, *Crocynia membranacea* ARL–22 and ARL–43, *Cladonia* sp. ARL–

27, *Lecanora subfusca* (L.). Ach. ARL–47, *Lecanora* sp. ARL–69, *Lepraria chlorina* Ach: ARL–34, *Ramalina farinacea* (L.) Ach. ARL–62, *Ramalina* sp. ARL–18, ARL–29 and ARL–64, *Stereocaulon* sp. ARL–1B and ARL–25, *Usnea* sp. ARL–63, and *Parmelia dactylifera* ARL–75.

TABLE 1.—*Antibiotic activities of lichen extracts.*

| Lichen Species | Diameter of zones of inhibition produced by the lichen extracts on growth of test microorganisms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Micrococcus pyogenes* Var. *aureus* 209 P | *Micrococcus pyogenes* var. *aureus* (Penicillin resistant) | *Bacillus subtilis* FDA 219 | *Escherichia coli* | *Salmonella gallinarum* | *Pseudomonas aeruginosa* | *Alcaligenes faecalis* | *Mycobacterium tuberculosis* 607 | *Candida albicans* | *Saccharomyces cerevisiae* | *Candotorulella paradoxa* | *Fusarium moniliforme* |
| | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm |
| *Buellia* sp. ARL–82 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 |
| *Crocynia membranacea* (Dicks) Zahlbr. ARL–22 | 30 | 25 | 40 | 0 | 0 | 0 | 0 | 33 | 0 | 21 | 16 | 0 |
| *Crocynia membranacea* (Dicks) Zahlbr. ARL–43 | 24 | 28 | 38 | 0 | 0 | 0 | 0 | 35 | 0 | 18 | 25 | 0 |
| *Cladonia* sp. ARL– 27 | 16 | 19 | 26 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 |
| Unidentified Graphidaceae ARL 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unidentified Graphidaceae ARL–39 | 19 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 0 |
| *Graphis scripta* (L.) Ach. group ARL–100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 |
| *Lecanora subfusca* (L.) Ach. ARL–47 | 40 | 30 | 35 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 25 | 0 |
| *Lecanora subfusca* (L.) Ach. ARL–91 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 |
| *Lecanora subfusca* (L.) Ach. ARL–92 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 |
| *Lecanora* sp. ARL–69 | 32 | 30 | 21 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 23 | 0 |
| *Lecanora varia* (Ehrh.) Ach. ARL 97 | 35 | 30 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 |
| *Lepraria chlorina* Ach. ARL 34 | 35 | 33 | 35 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 0 |
| *Leptogium* sp. ARL–87 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pannaria mariana* (Fr.) ARL–28 | 0 | 15 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Parmelia dactylifera* Vainio ARL–75 | 21 | 30 | 30 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 23 | 0 |
| *Parmelia collingeri* Hepp. ARL–93 | 26 | 25 | 26 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Parmelia reticulata* Tayl. ARL–96 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pertusaria* sp. ARL–79 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Physcia albicans* (Pers.) Thoms ARL 3 | 20 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Physcia albicans* (Pers.) Thoms ARL–33 | 20 | 22 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 20 | 0 |
| *Physcia picta* (Sw.) Nyl. ARL–60 | 28 | 18 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 0 |
| *Physcia picta* (Sw.) Nyl. ARL–70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Physcia* sp. ARL–45 | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Physcia* sp. ARL–102 | 0 | 0 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pyxine* sp. ARL–19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pyxine* sp. ARL–50 | 20 | 21 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pyxine* sp. ARL–55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0 |
| *Pyxine* sp. ARL–58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pyxine* sp. ARL–68 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pyxine* sp. ARL–95 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ramalina farinacea* (L.) Ach. group ARL–62 | 29 | 36 | 39 | 0 | 0 | 0 | 0 | 35 | 17 | 0 | 15 | 0 |
| *Ramalina* sp. ARL–18 | 23 | 30 | 32 | 22 | 0 | 0 | 0 | 19 | 0 | 19 | 0 | 0 |
| *Ramalina* sp. ARL–29 | 28 | 28 | 40 | 0 | 0 | 0 | 0 | 27 | 0 | 22 | 0 | 0 |
| *Ramalina* sp. ARL–64 | 30 | 33 | 30 | 19 | 0 | 0 | 0 | 34 | 0 | 17 | 0 | 0 |
| *Stereocaulon* sp. ARL–1B | 0 | 21 | 15 | 0 | 0 | 0 | 0 | 41 | 0 | 0 | 0 | 0 |
| *Stereocaulon* sp. ARL–25 | 30 | 30 | 29 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 |
| *Usnea* sp. ARL–63 | 28 | 26 | 30 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 |

Among the test fungi, *Ceratostomella paradoxa* appears to be the most sensitive to the antagonistic action of the extracts. It was inhibited by extracts from fourteen samples belonging to ten species, while *S. cerevisiæ*, by extracts of six samples from five species, and *C. albicans*, by only one. *F. moniliforme* was not affected at all by any of the extracts.

The organic solvents (acetone, benzene, butanol, ethanol, ether, methanol and petroleum ether) and NaOH-dextrose solution were almost equally efficient in extracting the antimicrobial principle active against *M. pyogenes* var. *aureus* (penicillin resistant) and *B. subtilis* FDA 219, as evidenced by the zones of inhibition (Table 2) produced by the extracts from the seven lichens mentioned ahead on the growth of these microorganisms. With the exception of *Stereocaulon* sp. ARL–1B, nearly all of the extracts from the other six lichens were also active against *M. pyogenes* var. *aureus* 209 P.

In the case of *Physcia albicans* ARL–33 (Table 2), it is possible that its antibiotic which is active against *M. pyogenes* var. *aureus* 209 P is not extractable by acetone, ethanol or methanol or may be its concentration is so low as not to cause any appreciable inhibition of the test microorganism. Burkholder, et al.,(4) Litvinov and Rassadina(11) and Liu, et al.,(12) who also used different organic solvents, found that the antibacterial substances from lichens could easily be extracted by ether, alcohol, acetone, benzene and gasoline.

In a chemical investigation of a selected antibiotically active Philippine lichens, several substances such as usnic acid, atranorin and chloratranorin were isolated, and were all found to have antibacterial properties. In this connection it might be mentioned that usnic acid was isolated in pure form from Polish lichens by Borkowski, et al.,(3) from Swiss lichens by Stoll, et al.,(19) and from Yugoslavian lichens by Benzinger, et al.,(2) and was reported to possess inhibitory power on gram-positive bacteria. Burkholder and Evans,(5) who obtained atranorin, fumaro-proto-cetraric acid and usnic acid from vials containing herbarium lichen specimens in Yale University, observed from their cylinder-plate tests that usnic acid produced inhibition of *B. subtilis*, but not of *S. aureus* or *B. coli*, while the first two compounds did not inhibit any of these organisms at all. Other lichen acids such as vulpinic acid, d-protolichesteric acid, lichesteric acid, dihydrolichesteric acid, physodic acid, and diffractic acid were reported by Stoll, et al.(18) as more or less strongly inhibitory to mycobacteria and gram-positive cocci.

TABLE 2.—*Antibiotic activity of organic-solvent extracts of lichens.*

| Species of lichen | Solvent | Diameter of zones of inhibition produced by the extracts on the growth of test microorganisms | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Micrococcus pyogenes* var. *aureus* 209 P | *Micrococcus pyogenes* var. *aureus* (Penicillin resistant) | *Bacillus subtilis* FDA 219 | *Escherichia coli* | *Salmonella gallinarum* | *Pseudomonas aeruginosa* | *Alcaligenes faecalis* | *Mycobacterium tuberculosis* 607 | *Candida albicans* | *Saccharomyces ceresiciae* | *Cratostomella paradoxa* | *Fusarium moniliforme* |
| | | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm |
| *Crocynia membranacea* (Dicks) Zahlbr. ARL-22 | NaOH-dextrose | 30 | 25 | 40 | 0 | 0 | 0 | 0 | 33 | 0 | 21 | 16 | 0 |
| | Acetone | 28 | 23 | 30 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 |
| | Benzene | 22 | 25 | 30 | 0 | 0 | 0 | 0 | 32 | 0 | 0 | 0 | 0 |
| | Butanol | 23 | 22 | 35 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 0 |
| | Ethanol | 28 | 24 | 30 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 0 |
| | Ether | 22 | 24 | 32 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 0 |
| | Methanol | 23 | 25 | 30 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 0 |
| | Petroleum ether | 26 | 26 | 35 | 0 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 0 |
| *Stereocaulon* sp. ARL-1B | NaOH-dextrose | 0 | 21 | 15 | 0 | 0 | 0 | 0 | 41 | 0 | 0 | 0 | 0 |
| | Acetone | 0 | 18 | 17 | 0 | 0 | 0 | 0 | 35 | 0 | 0 | 17 | 0 |
| | Benzene | 0 | 18 | 17 | 0 | 0 | 0 | 0 | 35 | 0 | 0 | 19 | 0 |
| | Butanol | 0 | 17 | 17 | 0 | 0 | 0 | 0 | 35 | 0 | 0 | 0 | 0 |
| | Ethanol | 0 | 18 | 19 | 0 | 0 | 0 | 0 | 35 | 0 | 0 | 0 | 0 |
| | Methanol | 0 | 16 | 19 | 0 | 0 | 0 | 0 | 35 | 0 | 0 | 19 | 0 |
| | Petroleum ether | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ramalina farinacea* (L.) Ach. group ARL-62 | NaOH-dextrose | 29 | 36 | 39 | 0 | 0 | 0 | 0 | 35 | 17 | 0 | 15 | 0 |
| | Acetone | 30 | 33 | 30 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 |
| | Benzene | 27 | 30 | 32 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 0 |
| | Butanol | 29 | 33 | 33 | 0 | 0 | 0 | 0 | 32 | 17 | 0 | 0 | 0 |
| | Ethanol | 30 | 34 | 29 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 |
| | Ether | 25 | 28 | 26 | 0 | 0 | 0 | 0 | 23 | 0 | 0 | 0 | 0 |
| | Methanol | 30 | 36 | 33 | 0 | 0 | 0 | 0 | 32 | 0 | 0 | 0 | 0 |
| | Petroleum ether | 23 | 24 | 35 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 |
| *Parmelia dactylifera* Vainio ARL-75 | NaOH-dextrose | 21 | 30 | 30 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 28 | 0 |
| | Acetone | 30 | 33 | 30 | 0 | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 0 |
| | Benzene | 28 | 30 | 26 | 0 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 0 |
| | Butanol | 30 | 35 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 0 |
| | Ethanol | 33 | 32 | 32 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 0 |
| | Ether | 27 | 26 | 27 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 |
| | Methanol | 30 | 28 | 30 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 |
| | Petroleum ether | 25 | 27 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Physcia albicans* (Pers.) Thoms ARL-33 | NaOH-dextrose | 20 | 22 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 20 | 0 |
| | Acetone | 0 | 17 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Benzene | 19 | 19 | 22 | 0 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 0 |
| | Butanol | 17 | 17 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Ethanol | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Ether | 17 | 18 | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Methanol | 0 | 17 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Petroleum ether | 18 | 18 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lecanora subfusca* (L.) Ach. ARL-47 | NaOH-dextrose | 40 | 30 | 35 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 25 | 0 |
| | Acetone | 26 | 25 | 35 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 0 |
| | Benzene | 25 | 27 | 33 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 |
| | Butanol | 20 | 21 | 36 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 |
| | Ethanol | 25 | 23 | 33 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 |
| | Ether | 24 | 25 | 32 | 0 | 0 | 0 | 0 | 23 | 0 | 0 | 0 | 0 |
| | Methanol | 23 | 23 | 33 | 0 | 0 | | | 23 | 0 | 0 | 0 | 0 |
| | Petroleum ether | 18 | 21 | 32 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 0 |
| *Usnea* sp. ARL-63 | NaOH-dextrose | 28 | 26 | 30 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 |
| | Acetone | 21 | 22 | 34 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 22 | 0 |
| | Benzene | 26 | 28 | 35 | 0 | 0 | 0 | 0 | 36 | 0 | 18 | 20 | 0 |
| | Butanol | 20 | 21 | 35 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 0 |
| | Ethanol | 18 | 19 | 35 | 0 | 0 | 0 | 0 | 29 | 0 | 0 | 0 | 0 |
| | Ether | 22 | 26 | 36 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 0 |
| | Methanol | 20 | 21 | 31 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 20 | 0 |
| | Petroleum ether | 24 | 26 | 36 | 0 | 0 | 0 | 0 | 35 | 0 | 0 | 0 | 0 |

The results of these studies on the chemical components of Philippine lichens and their antibiotic properties will be presented in a future article.

SUMMARY

Of the 38 extracts from 33 species of lichens tested for antimicrobial activity, 30 inhibited at least one of the 12 test microorganisms, consisting of 3 gram-positive, 4 gram-negative, and 1 acid-fast bacteria, 2 yeasts and 2 filamentous fungi. The gram-positive bacteria and *M. tuberculosis* 607 were found to be more sensitive to the active principle in the lichen extracts than the gram-negative bacteria.

Of the test fungi, *Ceratostomella paradoxa* was sensitive to the extracts, but yeasts and *Fusarium moniliforme* appeared resistant.

The antibiotic substances in lichens were readily extracted by organic solvents.

ACKNOWLEDGMENT

The authors are grateful to Misses L. M. Joson, Z. Bernardo and E. Tobias for assisting in the lichen collection, and to Prof. Flordeliz Uyenco of the Botany Department, University of the Philippines, for offering valuable suggestions during the course of this investigation. They are also grateful to Dr. Mason Hale of the Smithsonian Institution, Washington, D. C., for identifying the lichens.

REFERENCES

1. ASAHINA, Y., and N. KUTAMI. The lichen substances. The constituents of native lichens in Japan. Jour. Pharm. Soc. Japan No. 533 (1926) 531–545. Through CA 24: 504, 21: 2262.
2. BENZINGER, F., P. TOMASIC, and M. ZAVERSEK. Usninic acid from lichens of Yugoslavia and its antibiotic activty. Qualitas Plant. et, Materiæ vegetabiles 7: 371–383. Through CA 55 (1960 10594.
3. BORKOWSKI, B., H. GERTIG, and J. JELJASZEWICZ. Yield and activity of antibiotics from some Polish lichens. Dissertations Pharm. 10: 29–107. Through CA 52 (1958) 18700.
4. BURKHOLDER, P. R., A. W. EVANS, L. MCVEIGH, and H. K. THORNTON. Antibiotic activity of lichens. Proc. Nat. Acad. Sci. 30 (1944) 250–255.
5. BURKHOLDER, P. R., and A. W. EVANS. Further studies on the antibiotic activity of lichens. Bull. Torrey Bot. Club 72 (1945) 157.
6. BURKHOLDER, P. R., L. M. BURKHOLDER, and L. R. ALMODOVAR. Antibiotic activity of some marine algæ of Puerto Rico. Bot. Mar. 2 (1960) 149–155.

7. DAHL, E. The use of lichen chemistry in lichen systematics. Proc. Intern. Bot. Cong. Stockholm 1950 7 (1954) 810–811. Through CA 49: 4806.
8. HALE, E. Chemical strains of the lichen Parmelia furfuracæ. Amer. Jour. Bot. 43 (1956) 456–459.
9. HERRE, A. W. The lichen flora of the Philippines. Jour. Arn. Arb. Harv. Univ. 27 (1948) 408–412.
10. HERRE, A. W. New records of Philippine and other tropical Pacific lichens with descriptions of five new species. Philip. Jour. Sci. 86 (1958) 13–55.
11. LITVINOV, M. A., and K. A. RASSADINA. Experimental investigation of antibiotic properties of lichens from the U. S. S. R. Bot. Zhur. 43 (1958) 557–560. Through CA 52 : 11892.
12. LIU, SHU-HSUN, LI-CHUN-SHEN, LIANG CH'UAN LI, and JUN-SHENG TS-AI. Usnic acid isolated from Chinese lichens. K'o Hsuch Tung Pao. 527–8. Through CA 54 (1960) 13274.
13. PRATT, R., T. C. DANIELS, J. J. EILER, J. B. GUNNISON, W. D. KUMLER, F. ONETO, and L. A. STRAIT. Chlorellin, an antibacterial substance from Chlorella. Science 99 (1944) 351–352.
14. PRATT, R., H. MAUTNER, G. M. GARDNER, YI-HSIEN SHA, and J. DUFRENOY. Report on antibiotic activity of seaweed extracts. Jour. Amer. Pharm. Assoc. 40 (1951) 575–579.
15. QUISUMBING, E. Medicinal plants of the Philippines. Bur. of Print. (1951) 1234 pp.
16. SESHADRI, T. R. Chemical investigation of Indian lichens. Indian Jour. Pharm. 15 (1953) 286–287. Through CA 49 : 4763.
17. SMITH, GEORGE. An introduction of industrial mycology. Third Edition. London: Edward Arnold & Co., Ltd. 1946. xiv + 271 pp.
18. STOLL, A., J. RENZ, and A. BRACK. Antibiotika aus Fletchen. Experientia 3 (1947) 111–114.
19. STOLL, A., J. RENZ, and A. BRACK. Die antibakterielle wirkung der usninsaure auf mykobakterien und andere mikroorganismen. Experientia 3 (1947) 115–117.
20. WAINIO, E. A. Lichenes insularum Philippinarum I. Philip. Jour. Sci. § C 4 (1909) 651–662.
21. WAINIO, E. A. Lichenes insularum Philippinarum II. Philip. Jour. Sci. § C 8 (913) 99–137.
22. WAINIO, E. A. Lichenes insularum Philippinarum III. Ann. Acad. Sci. Fenn. Ser. A 15 (1921) 1–368.
23. WAINIO, E. A. Lichenes insularum Philippinarum IV. Ann. Acad. Sci. Fenn. Ser. A 19 (1923) 1–84.

# ILLUSTRATIONS

PLATE 1

FIG. 1. *Pannaria mariana* Fr. ARL–28 collected from the bark of a tree growing on the slope of Mayon Volcano.

2. *Parmelia dactylifera* Wainio ARL–75 collected from the bark of a tree in Baguio City.

PLATE 2

FIG. 1. *Lecanora subfusca* group ARL–47 collected from the bark of a tree on campus of University of the Philippines, Diliman, Quezon City.

2. *Stereocaulon* sp. ARL–25 collected from a rock on Mayon Volcano.

PLATE 3

FIG. 1. Showing the antimicrobial activities of NaOH-dextrose extracts from four lichens in a plate seeded with *B. subtilis*: No. 1 *Physcia picta* (Sw.) Nyl ARL–60 and No. 3 *Parmelia dactylifera* Wainio ARL–75 producing distinct clear inhibition zones around the perforations: No. 2 *Physcia albicans* (Pers.) Thoms ARL–3, no inhibition: and No. 4 *Parmelia zollingeri* Hepp. ARL–93 producing an inhibition zone smaller than No. 1 and No. 3.

2. Showing the inhibition produced by NaOH-dextrose extract of *Lecanora subfusca* (L.) Ach. ARL–47 on growth of *Mycobacterium tuberculosis* 607 in an assay plate seeded with the latter.

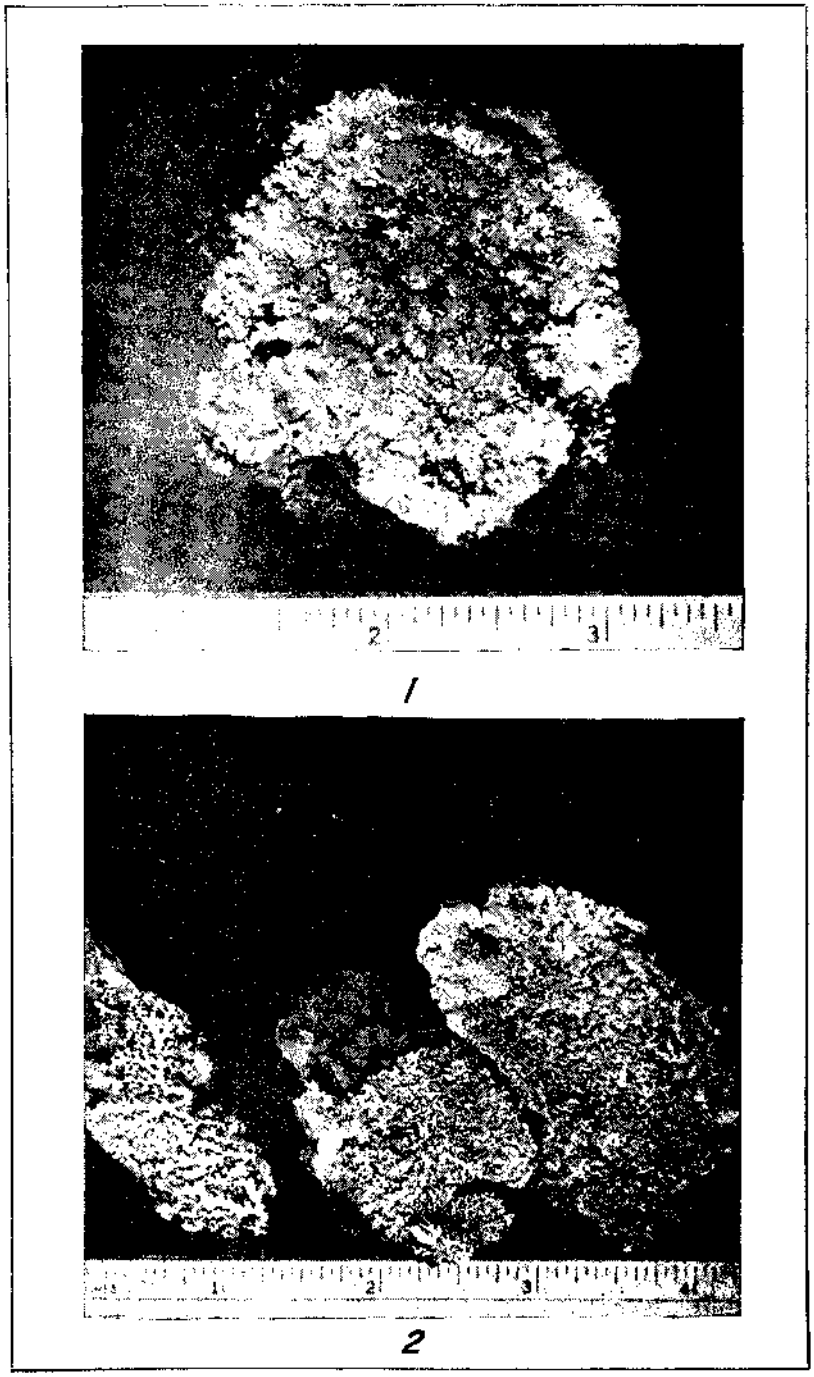
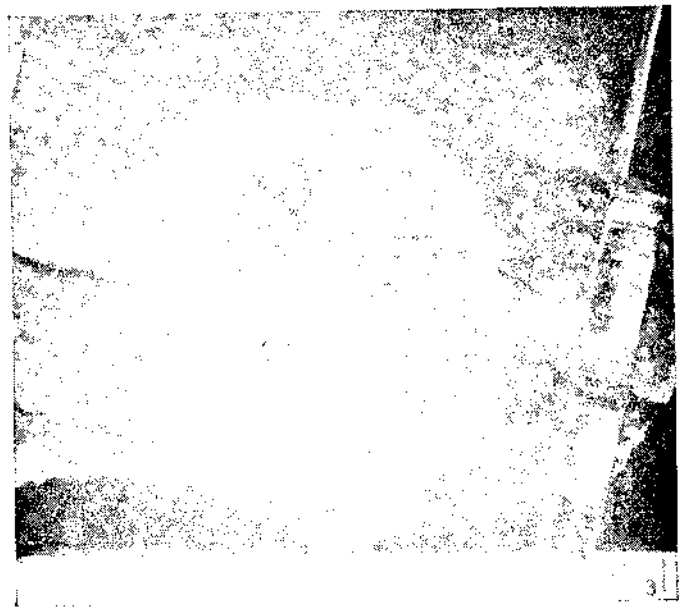
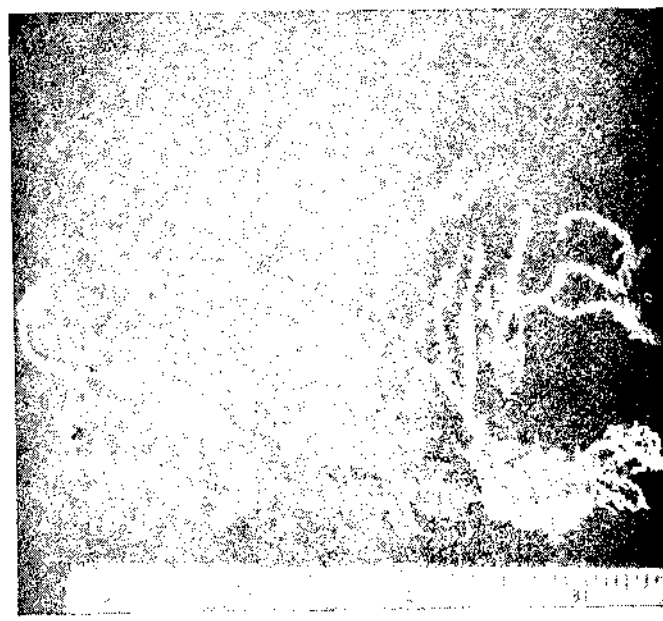



PLATE 1.

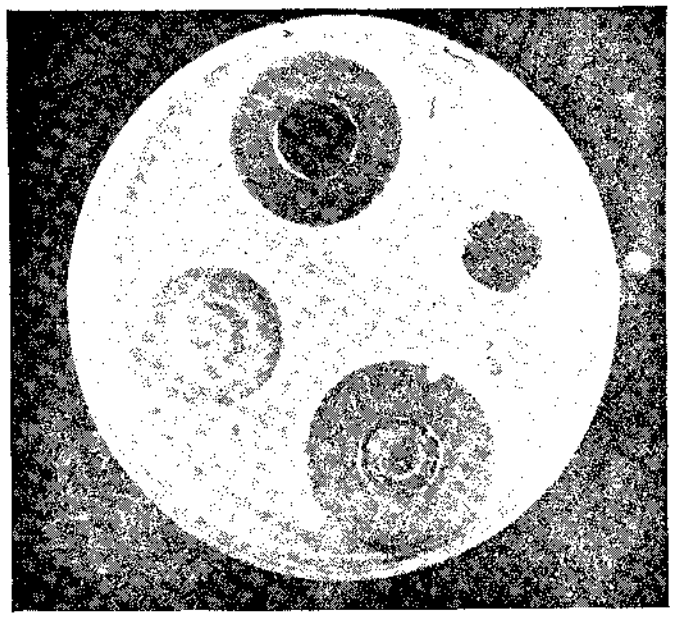


1

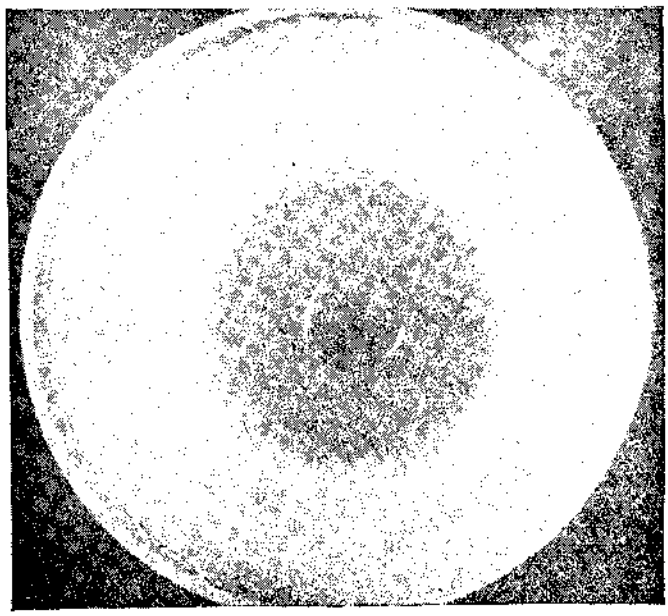


2

PLATE 2.



1



2

PLATE 3.

# ASCORBIC ACID RETENTION IN BOTTLED FORTIFIED ORANGE JUICE DURING PROCESSING AND STORAGE

By ESTELITA M. PAYUMO and PACITA L. MANIQUIS
*National Institute of Science and Technology, Manila*

(Received for publication, February 20, 1964.)

TWO TEXT FIGURES

Citrus fruit juices, from a nutritional standpoint, are primarily valued for their ascorbic acid content. This nutrient, however, as an important dietary requirement, is generally known to be one of the most unstable vitamins, being easily affected by heat, oxidation, and the use of metallic utensils, among others. While controlled commercial processes have, so far, been able to limit ascorbic acid loss to a minimum, storage conditions still account for a large percentage of this loss, especially at elevated temperatures.

Vitamin C retention in stored citrus fruit juices is dependent on both time and temperature, as investigators have shown. (3, 4, 5, 7, 8, 10, 11) The most satisfactory temperature for storing canned orange juice, from the standpoint of cost as well as the retention of its quality and ascorbic acid content, has been found to be between 4° and 10°C. It has also been found (9) that the retention of ascorbic acid in bottled orange juice prepared under laboratory conditions in the absence of specialized equipment for fruit juice processing was higher at refrigerated temperature storage than that at room temperature.

On the assumption that by increasing the vitamin C level of fruit juice by the addition of the synthetic vitamin during processing correspondingly increases the residual ascorbic acid level after subsequent storage, this study was undertaken to determine the retention of ascorbic acid in fortified orange juice prepared under ordinary laboratory conditions and stored for a period of 6 months at 2 ranges of temperature; namely, room temperature (29° to 31°C) and refrigerated temperature (4° to 5°C).

## EXPERIMENTAL PROCEDURE

Juice from native oranges, *Citrus nobilis* Lour. (Szinkum mandarin) was extracted by cutting the previously washed fruits into halves and squeezing them with the use of an ordinary household juice extractor. The juice was strained through muslin cloth to remove the seeds and residual pulp. The filtered juice was treated with sodium benzoate to obtain a 0.05 per cent concentration in the juice, heated rapidly in an

aluminum kettle to 85°C and held at that temperature for 3 minutes. Ascorbic acid, equivalent to 50 mg per 100 ml of juice was added to the juice as soon as the temperature of pasteurization reached 85°C, or just prior to the bottling process. The pasteurized juice was immediately put into previously sterilized bottles of the crown-closure type. Any foam on the surface was removed and replaced with hot juice. The bottles were immediately sealed and cooled with running water. The bottles, labeled as Sample I, were then divided into two lots and stored for a period of 24 weeks. One lot was kept at room temperature (approximately 30°C) and the other, in an ordinary refrigerator (4° to 5°C).

To another batch, Sample II, of filtered juice extracted by the same method, 100 mg of ascorbic acid per 100 ml of juice was added before processing in the same manner as in Sample I. The bottles were likewise stored at the same period and storage conditions.

*Examination of juices.*—Ascorbic acid determination were made on the fresh juice and on the pasteurized fortified juices after bottling, with the use of the indophenol titration method. (1) At 6 weeks interval during storage, samples of each of the lots from Samples I and II were taken for ascorbic acid analyses. The refrigerated samples were always brought to room temperature before analyses were made. Color changes by visual observation were noted during the storage period.

## RESULTS AND DISCUSSION

Table 1 and Figs. 1 and 2 shows, respectively, the ascorbic acid contents and percentage of retention of ascorbic acid in orange juice fortified at two different levels; namely, 50 and

TABLE 1.—*Ascorbic acid content of fortified bottled orange juice during storage at two ranges of temperature.*

| Sample | Ascorbic acid after processing mg/100 cc | Ascorbic acid mg/100 cc | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 6 weeks | | 12 weeks | | 18 weeks | | 24 weeks | |
| | | RT * | R ** | RT * | R ** | RT * | R ** | RT * | R ** |
| I Orange juice + 50 mg ascorbic acid/ 100 cc | 81.66 | 76.73 | 79.25 | 69.50 | 75.21 | 69.19 | 74.40 | 65.62 | 74.29 |
| II Orange juice + 100 mg ascorbic acid/ 100 cc | 124.12 | 102.17 | 108.62 | 101.04 | 104.42 | 97.28 | 104.14 | 94.87 | 103.32 |

* Room temperature

** Refrigerator temperature

100 mg per cent (Samples I and II), and stored at 2 ranges of temperature.

The average ascorbic acid content of the fresh juice was 32.46 mg per cent. After pasteurization of the fortified juice, (Sample I) its ascorbic acid content was 81.66 mg per cent showing a retention of 99.03 per cent. Retention in Sample II was 93.7 per cent with an ascorbic acid content of 124.12 mg per cent. Calculations were based on the difference between the amount of ascorbic acid originally present in the juice plus the added ascorbic acid and the residual ascorbic acid after processing.

Retention of ascorbic acid in Sample I during the period of 6, 12, 18 and 24 weeks at room temperature was 93.96, 85.11, 84.73, and 80.36 per cent, respectively. In the refrigerated samples, the corresponding values were 97.05, 92.1, 91.11, and 90.97 per cent, respectively.

Retention of ascorbic acid in juice fortified at the concentration of 100 mg per cent (Sample II) during the period

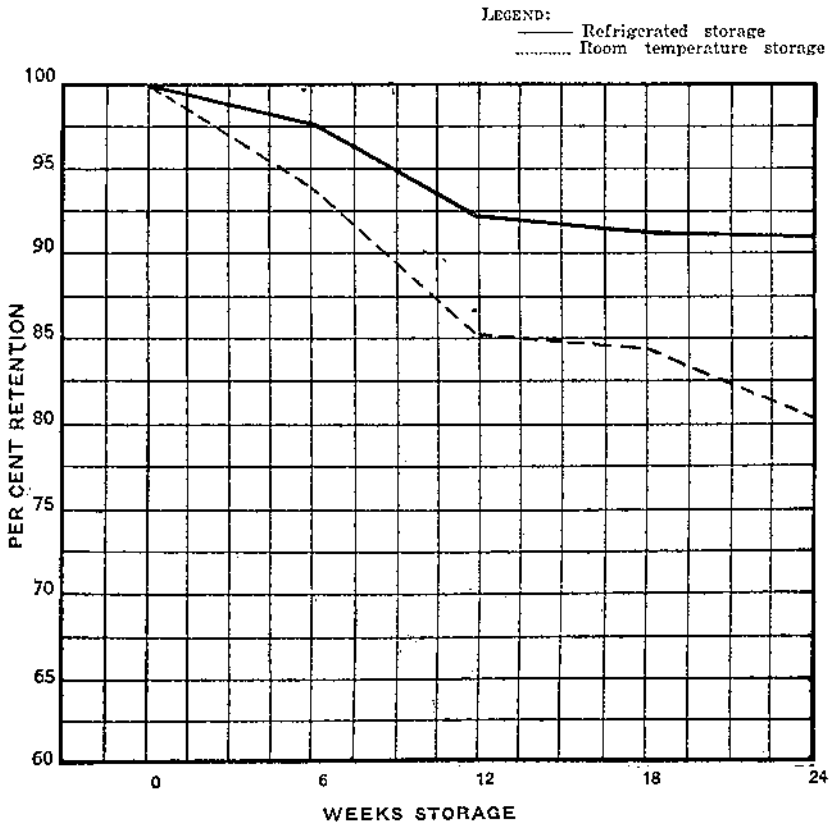



FIG. 1. Percentage retention of added ascorbic acid (50 mg./100 ml) in bottled orange juice on storage for six months (24 weeks).

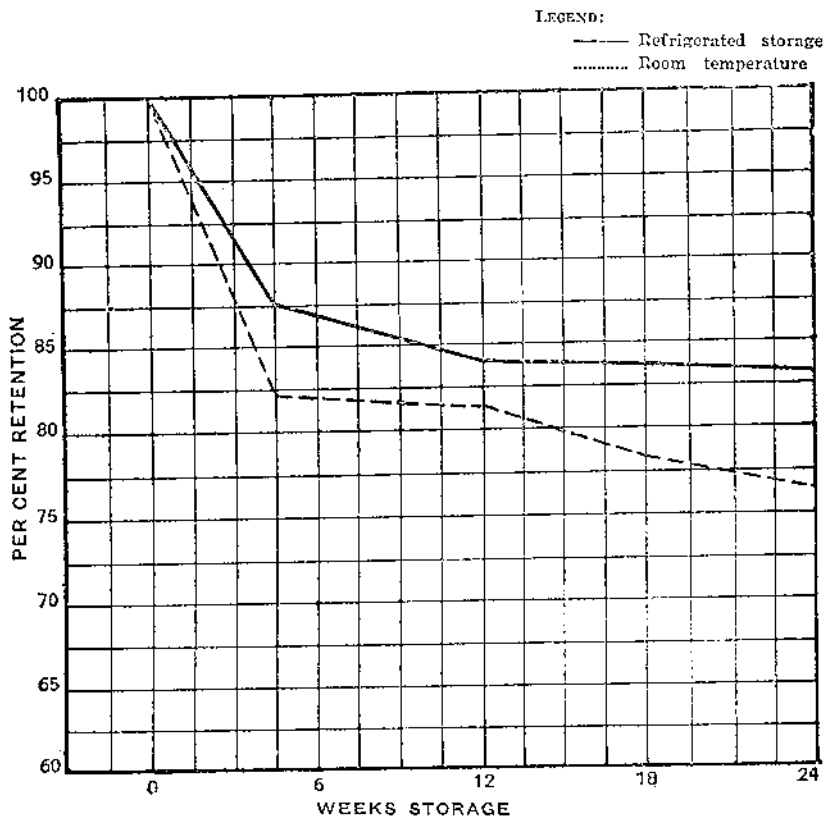



FIG. 2. Percentage retention of added ascorbic acid (100 mg./100 ml) in bottled orange juice on storage for six months (24 weeks).

of 6, 12, 18 and 24 weeks at room temperature was 82.32, 81.40, 78.38, and 76.43 per cent, respectively. At refrigerator temperature storage, the corresponding values were 87.51, 84.13, 83.90, and 83.24 per cent, respectively.

It will be noted that ascorbic acid loss was greatest during the first few months (12 weeks) of storage and then decreased gradually after the 12th week for Sample I in both storage temperatures. Similarly, loss of ascorbic acid in Sample II was greatest up to the 6th week of storage but decreased gradually thereafter. This may be explained by the fact that during the period that any free oxygen sealed in the container is being consumed, as during the first few months of storage after packing, ascorbic acid destruction appears to be more rapid than in subsequent storage.(6)

The loss of ascorbic acid in the sample fortified with 100 mg per cent of ascorbic acid was observed to be much greater than the loss in the sample fortified with 50 mg per cent,

even after processing. This phenomenon may be related to the findings of Beattie, et al.(2) on the effects of adding ascorbic acid to fruit juices containing colored pigments, who reported that increasing the concentration of ascorbic acid or isoascorbic acid increases the rate of loss of ascorbic acid.

From visual observations, the refrigerated juices changed color very slightly during the 24-week storage period. Juices stored at room temperature, however, began to turn slightly dark orange from the second month of storage, changing to orange-brown at the end of the 24-week storage period. Progessive darkening of citrus juice, which occurs much faster in nonrefrigerated storage, has been attributed to the interaction of various constituents of the fruit juice, such as amino acids, protein, sugar, ascorbic acid and fruit acids.(13)

Flavor changes were not followed in the study since comparative acceptability tests were made on bottled orange juice in a previous study(9) and it was assumed that added ascorbic acid would not introduce any objectionable flavor to the juice, especially at low levels. Shillinglaw, et al.(12) have reported that ascorbic acid added to true fruit orange and grapefruit beverages at the rate of 0.1 gm per 6 oz. bottle or 50 mg/90 cc juice or in concentrations in excess of that required to take up the free oxygen in the container distinctly increased the period of retention of the normal taste and flavor. However, a slight lowering of the pH value was noted in both samples after fortification, i.e., from 2.6 to 2.5 for Sample I and from 2.6 to 2.35 for Sample II.

## SUMMARY AND CONCLUSION

Bottled orange juice prepared from native oranges, *Citrus nobilis* Lour. (Szinkum mandarin) by simple laboratory methods was fortified with ascorbic acid at 2 different levels, i.e., 50 mg per cent and 100 mg per cent. Samples from the fortified juices were stored at room temperature and in the refrigerator, and their ascorbic acid contents were analyzed periodically every 6 weeks for a period of 24 weeks.

In the bottled orange juice fortified with 50 mg per cent of ascorbic acid, retention after processing was 99.03 per cent; in the juice fortified with 100 mg per cent of ascorbic acid retention was 90.7 per cent.

Refrigerated storage favored the retention of ascorbic acid at both levels of fortification.

The stability of ascorbic acid is low when the concentration of ascorbic acid is high.

031610—2

ACKNOWLEDGMENT

Sincere appreciation is hereby expressed to Dr. Conrado R. Pascual and the members of the Technical Committe of the Food and Nutrition Research Center for their valuable suggestions in the preparation of this report, to Mrs. Leonarda M. Pilac for performing some of the analyses, and to other members of the Food Research Laboratory who in one way or another helped in the preparation of this paper.

REFERENCES

1. Association of Official Agricultural Chemists. Methods of Analysis. A.O.A.C. Seventh Ed. George Banta Publishing Co., Manasha, Wis. (1950) 932 pp.
2. BEATTIE, H. G., K. A. WHEELER, and C. S. PEDERSON. Changes occurring in fruit juices during storage. Food Res. 8 (1943) 395–404.
3. BRENNER, S., V. O. WODICKA, and S. G. DUNLOP. Effect of high temperature storage on the retention of nutrients in canned foods. Food Tech. 2 (1948) 207–221.
4. EVENDEN, W., and G. L. MARSH. Effect of storage temperature on retention of ascorbic acid in orange juice. Food Res. 13 (1948) 244–253.
5. FEASTER, J. F. Effect of Commercial Storage on the Nutrient Content of Processed Foods. Nutritional Evaluation of Food Processing. Edited by R. S. Harris and H. von Loesecke, John Wiley and Sons, Inc., N. Y. (1960) 337–390.
6. FEASTER, J. F., M. D. TOMPKINS, and W. E. PEARCE. Effect of storage on vitamins and quality in canned foods. Food Res. 14 (1949) 25–39.
7. LEE, F. A., W. B. ROBINSON, J. C. HENING, and C. S. PEDERSON. Low temperature preservation of fruit juices and fruit juice concentrates. New York State Agri. Expt. Station Bull. (1950) 743.
8. MOSCHETTE, D. S., W. F. HINMAN, and E. G. HALLIDAY. Effect of time and temperature of storage on vitamin C content of commercially canned fruit and fruit juices (stored 12 months). Ind. Eng. Chem. Ind. Ed. 39 (1947) 994–999.
9. PAYUMO, E. M., and A. L. LINGAO. Effect of storage conditions on ascorbic acid and quality of bottled orange juice. Nutr. News, XIII 4 (1960) 28–34.
10. PRUTHI, J. S., R. P. SINGH, and G. Lal. Some nutritional aspects of fruit and fruit products. Indian Food Packer (13) 11 (1959) 14–16.
11. ROSS, E. Effect of time and temperature of storage on vitamin C retention in canned citrus juices. Food Res. 9 (1944) 27–33.
12. SHILLINGLAW, C. A., and M. LEVINE. Control of oxidative flavors in beverages. Food Res. 8 (1943) 453–463.
13. TRESSLER, D. K., and M. A. JOSLYN. The Chemistry and Technology of Fruit and Vegetable Juice Production. The Avi Publishing Co. Inc., New York (1954) 962 pp.

# THE EFFECT OF VARIOUS COOKING PROCEDURES ON COOKING LOSSES AND RETENTION OF B-VITAMINS IN PORK AND BEEF

By ANITA R. ISBERTO, ALICIA P. BAUTISTA, CARLITA C. GERVASIO, and LEOGARDA B. DIMAUNAHAN
*National Institute of Science and Technology, Manila*

(Received for publication, April 1, 1964.)

ONE TEXT FIGURE

Several studies previously undertaken abroad have shown that cooking methods or procedures have definite effects as regards cooking losses and B-vitamin retention. Cover(3) studied cooking losses in roasted beef round; Hinman, et al.(6) determined cooking loses in meat stewed in pressure saucepan. Clark and Duyne(2) reported cooking losses in top round beef, oven roasted and cooked in pressure saucepan. Tucker and co-workers(15) in a study on the retention of thiamine and riboflavin during braising, frying and broiling found that total retention depended on cooking time. Asp, et al.(1) found that cooking methods produced significant differences in both thiamine and riboflavin retention in veal.

This study is concerned with the effects of cooking methods on cooking losses and retention of B-vitamins in pork and beef. More specifically, it is aimed at determining the comparative cooking losses and B-vitamin retention due to certain cooking procedures. It also seeks to investigate B-vitamin retention not only with respect to the cooking procedure used, but also in relation to temperature, length of cooking time and amount of liquid used in cooking, and, like the above mentioned studies, to obtain data on the nutritive value of locally cooked foods through the use of conversion factors for cooking losses.

## MATERIALS AND METHODS

The cooked meat was separated from the drippings or liquid and then cooled. After cooling, the cooked meat and its liquid or drippings were measured and weighed separately, homogenized in a Waring blendor, stabilized with 1 per cent oxalic acid and then submitted for chemical analyses. The percentage retention was calculated from the difference between the vitamin content of the raw sample and that of the cor-

responding cooked sample. The vitamin value for the raw meat was used as a control for each method rather than the average for all the raw samples. The percentage retention reported was the average of three replicates.

Under the various cooking procedures, meat was cooked to equal fork tenderness, i.e. the meat does not fall to pieces nor is too tough when pierced with a fork. Cooking time for each trial was recorded, the time reported being the average of three replicates.

## COOKING PROCEDURES

A. Broiling is a dry-heat method of cooking which is done by direct heat either over hot coals or, as in a modern range, under a gas flame or an electric heating unit.(11) Broiling over hot charcoal was used in this study since this is the common local way of broiling. Six hundred grams of charcoal was kindled and when red-hot, the broiling rack holding the meat was set two inches above the source of heat. The meat was cooked until nicely brown on one side then turned over and cooked on the other side to the desired degree of doneness. "Well-done," i.e. the inner portion is cooked with no trace of raw meat juice, is generally preferred. The best test for doneness is to cut a small slit halfway at the center of the broiled meat and note the color and degree of doneness.

B. Frying is cooking in a small amount of fat in an uncovered container.(11) Fifty grams cooking fat was melted in a hot, heavy skillet and heated to 350°F. A thermometer was clipped into the side of the pan making sure the bulb was below the surface of the melted fat but not touching the bottom of the pan. Four hundred grams meat was fried for two minutes on each side, moving it once in a while to prevent it from burning. The temperature was maintained at 325°F until the meat was fork tender.

C. Braising is moist-heat cooking in which a small amount of liquid is used to continue and complete cooking after the meat has been browned in a small amount of fat.(11) Braising is done in a covered container. The purpose of braising is to provide longer, slower cooking in moist heat in order to soften the connective tissues.

Thirty grams cooking fat was melted in hot, heavy skillet and heated to 350°F. Four hundred grams meat was fried for two minutes on each side for an even browning, and water

was added. The amounts of water added ranged from 200 to 300 cc for pork and from 300 to 400 cc for beef. Cooking was continued at simmering temperature (185° to 200°F) until the meat was fork tender.

D. Cooking in water is moist-heat cooking in which more water is used.(11) Meat with more connective tissues is made tender by long, slow cooking in water in a covered container. A measured amount of water was boiled before the meat was placed in a covered container and cooked until tender at different temperatures: (*a*) simmering (185° to 200°F), and (*b*) boiling (212°F). The cover of a pressure saucepan cooker was used and a thermometer was inserted in the outlet vent for temperature readings.

## METHODS USED FOR CHEMICAL ANALYSIS

Thiamin and riboflavin were analyzed by the Hennessy and Cerecedo thiochrome method as reported by Munsell, et al.,(12) and by the flourometric method of Hodson and Norris,(5) respectively.

Niacin was analyzed by the U.S. Pharmacopoeia Microbiological Method(14) with the use of L. arabinosus.

## RESULTS AND DISCUSSION

*Cooking losses.*—In determining cooking losses, the different cuts and sizes of meat used in various cooking procedures were taken into consideration. Thus, small cubes are boiled as in soup; braised as in sauteed vegetables, *menudo* and *dinuguan;* broiled in sticks and fried. Bigger cuts are boiled as in *sinigang, puchero* and *nilaga;* braised as in *asado;* broiled and fried. The number of pieces of meat per 400-gram sample ranged from 4 to 11, with 6 pieces as the average number for the different methods of preparation for both pork and beef. Loss in weight and shrinkage was noted and determined. However, determination of shrinkage by measurement without a caliper did not show satisfactory results; hence, the reported percentage shrinkage was the percentage loss in weight.

In general, pork indicated higher percentage shrinkages under broiling and frying than under simmering, boiling and braising (except liver and braised lean pork, small cubes, Fig. 1). This trend was especially noted in the case of broiled and fried chop and shoulder compared to those simmered, boiled and braised, wherein the differences were significant. Broil-

ing and frying are usually done at higher temperatures with shorter cooking time, hence the cooking weight losses are higher. In this case, cooking temperature rather than length of cooking time had a direct effect on shrinkage which is in agreement with the finding of Lowe.(8)

Lean cuts of pork showed greater percentage shrinkage under all cooking methods used, compared to chop and shoulder (except fried and broiled shoulder, Fig. 1). This is particularly true in the case of simmering, boiling, and braising under which the lean cuts indicated losses from 41 to 52 per cent, while chop and shoulder indicated losses from 23 to 39 per cent. It was also noted that in lean pork, smaller cuts showed higher percentage shrinkage than bigger cuts in all methods of cooking, although the differences were not significant. In particular, smaller cuts showed an average of 50 per cent shrinkage for both frying and broiling; while bigger cuts showed 48 and 45 per cent, respectively. Shrinkage in pork liver in all cooking methods was nearly constant at 47 per cent, except in frying where shrinkage was less.

In beef the percentage shrinkages by various cooking methods ranged from 42 to 48 per cent which corresponded in direct proportion to cooking time (except braising). Unlike with pork, the percentage shrinkages under moist-heat cooking are slightly greater than under dry-heat cooking.

The percentage loss by evaporation was determined as in the studies made by Leverton(7) with the use of the following formula:

$$\frac{\text{raw wt. (plus water if added during cooking less cooked wt.}}{\text{raw wt. (plus water if added during cooking)}} \times 100$$

Loss by evaporation was greater in moist-heat cooking than in dry-heat cooking (Table 1). Among moist-heat cooking methods, boiling showed the greatest evaporation which was directly proportional to temperature rather than to cooking time.

The cooking losses determined in this study were higher than those reported by Cover, et al. of 32.6 per cent in roasted beef;(3) Clark and Duyne, 30 per cent in top round beef, oven-roasted and 36 per cent pressure saucepan cooked;(2) and Hinman and Halliday, 40 per cent in stewed meat, pressure saucepan.(6) Our study used smaller cuts, thus exposing more cooking losses as compared to the aforementioned studies.

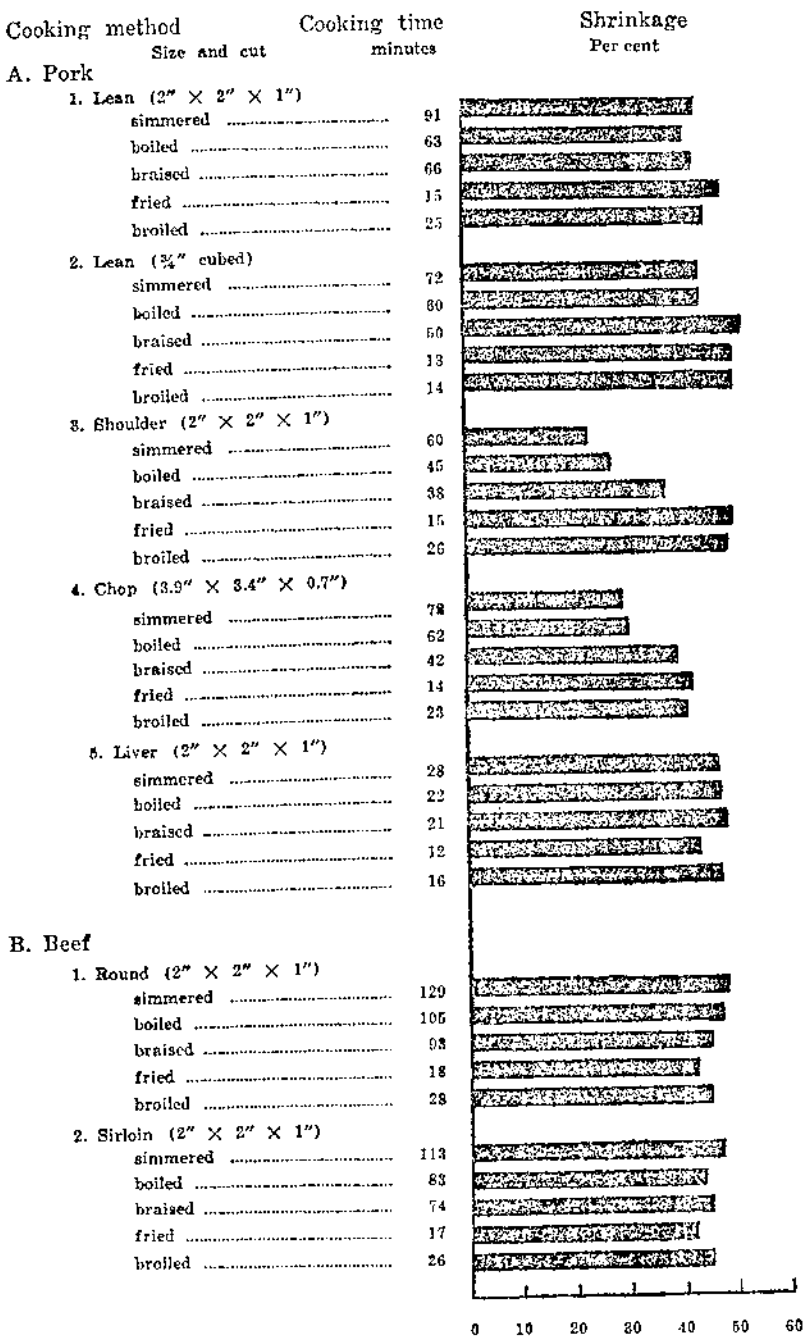



FIG. 1. Cooking time and percentage shrinkage of pork and beef cooked by various methods.

TABLE 1.—*Percentage weight loss by evaporation of meat in moist-heat and dry-heat cooking.*

| Sample | Moist-heat cooking | | | | | | | | | | | | Dry-heat cooking | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Simmered | | | | Boiled | | | | Braised | | | | Fried | | | | Broiled | | | |
| | $H_2O$ Added | Cooking time | Cooked weight | Loss by evaporation | $H_2O$ Added | Cooking time | Cooked weight | Loss by evaporation | $H_2O$ Added | Cooking time | Cooked weight | Loss by evaporation | $H_2O$ Added | Cooking time | Cooked weight | Loss by evaporation | $H_2O$ Added | Cooking time | Cooked weight | Loss by evaporation |
| A. PORK | *gm* | *min* | *gm* | *Per cent* | *gm* | *min* | *gm* | *Per cent* | *gm* | *min* | *gm* | *Per cent* | *gm* | *min* | *gm* | *Per cent* | *gm* | *min* | *gm* | *Per cent* |
| 1. Lean: (a) 1/4" cubed | 666 | 73 | 224 | 79 | 1,066 | 60 | 225 | 85 | 233 | 59 | 192 | 70 | ------ | 13 | 193 | 50 | ------ | 14 | 200 | 50 |
| (b) 2" × 2" × 1" | 666 | 91 | 229 | 78 | 1,166 | 63 | 223 | 85 | 266 | 66 | 223 | 66 | ------ | 15 | 207 | 48 | ------ | 25 | 232 | 42 |
| 2. Shoulder w/skin | 933 | 60 | 309 | 77 | 1,000 | 45 | 293 | 79 | 200 | 33 | 251 | 58 | ------ | 15 | 202 | 50 | ------ | 26 | 202 | 50 |
| 3. Chop | 500 | 78 | 239 | 73 | 1,100 | 62 | 217 | 86 | 200 | 42 | 192 | 68 | ------ | 14 | 186 | 54 | ------ | 23 | 221 | 44 |
| 4. Liver | 500 | 28 | 211 | 76 | 500 | 22 | 212 | 76 | 200 | 21 | 205 | 66 | ------ | 12 | 231 | 42 | ------ | 16 | 227 | 43 |
| B. BEEF | | | | | | | | | | | | | | | | | | | | |
| 1. Round | 1,000 | 129 | 204 | 85 | 2,166 | 105 | 213 | 92 | 400 | 93 | 221 | 72 | ------ | 18 | 231 | 42 | ------ | 23 | 221 | 45 |
| 2. Sirloin | 1,333 | 113 | 214 | 86 | 1,833 | 83 | 224 | 90 | 366 | 74 | 213 | 72 | ------ | 17 | 232 | 42 | ------ | 26 | 222 | 44 |

*Conversion factors.*—The conversion factors were determined to help in obtaining an accurate appraisal of cooked foods in dietary evaluation with the use of the following formula:

$$\frac{\text{raw weight}}{\text{cooked weight}} = \text{Conversion factor}$$

The conversion factors in the different cuts of meat cooked by various methods are given in Table 2. Beef showed higher figures with an average of 1.93 and 1.83 under simmering and boiling, respectively, compared to pork which showed an average of 1.63 and 1.65 for the same cooking methods. However, pork showed higher figures under frying, broiling and braising with an average of 2.02, 1.93 and 1.89, respectively, compared to 1.74, 1.82, and 1.83 in beef for said cooking methods.

TABLE 2.—*Conversion factors in meat cooked by various methods.*

| Sample cut | Simmering | Boiling | Braising | Frying | Broiling |
|---|---|---|---|---|---|
| A. PORK | | | | | |
| 1. Lean: | | | | | |
| (a) ¼" cubed | 1.78 | 1.78 | 2.27 | 2.02 | 2.00 |
| (b) 2" × 2" × 1" | 1.76 | 1.77 | 1.80 | 1.95 | 1.78 |
| 2. Shoulder with skin | 1.81 | 1.37 | 1.60 | 1.99 | 1.99 |
| 3. Chop | 1.66 | 1.66 | 1.88 | 2.12 | 2.01 |
| Average | 1.63 | 1.65 | 1.89 | 2.02 | 1.93 |
| 4. Liver | 1.90 | 1.89 | 1.95 | 1.74 | 1.78 |
| B. BEEF | | | | | |
| 1. Round | 1.96 | 1.83 | 1.81 | 1.74 | 1.81 |
| 2. Sirloin | 1.89 | 1.78 | 1.85 | 1.73 | 1.83 |
| Average | 1.93 | 1.83 | 1.83 | 1.74 | 1.82 |

TABLE 3.—*Thiamine, riboflavin and niacin content of different cuts of raw meat.*

| Sample cut | Thiamine (mg/100 gm) | | Riboflavin (mg/100 gm) | | Niacin (mg/100 gm) | |
|---|---|---|---|---|---|---|
| | Range | Average | Range | Average | Range | Average |
| A. PORK | | | | | | |
| 1. Lean: | | | | | | |
| (a) ¼" cubed | 0.23–0.66 | 0.48 | 0.30–0.36 | 0.33 | 5.20–9.50 | 7.22 |
| (b) 2" × 2" × 1" | 0.43–0.63 | 0.49 | 0.20–0.46 | 0.30 | 4.70–8.30 | 5.64 |
| 2. Shoulder with skin | 0.21–0.55 | 0.39 | 0.15–0.37 | 0.23 | 2.60–5.10 | 3.61 |
| 3. Chop | 0.21–0.38 | 0.30 | 0.16–0.17 | 0.17 | 3.70–5.30 | 4.26 |
| 4. Liver | 0.25–0.23 | 0.27 | 1.83–5.65 | 3.32 | 7.40–8.20 | 7.74 |
| A. BEEF | | | | | | |
| 1. Round | 0.03–0.05 | 0.04 | 0.05–0.23 | 0.14 | 6–50–8.00 | 7.35 |
| 2. Sirloin | 0.02–0.19 | 0.09 | 0.08–0.29 | 0.21 | 5.80–8.00 | 6.77 |

*Vitamin content of raw meat.*—The vitamin values for the raw samples are given in Table 3. As may be noted

TABLE 4.—*Thiamine, riboflavin and niacin retention in pork and beef cooked by various methods.*

| Sample | Methods of cooking | Thiamine | | | | | Riboflavin | | | | | Niacin | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Raw | Cooked | | Retention | | Raw | Cooked | | Retention | | Raw | Cooked | | Retention | |
| | | | Meat | Liquid or drippings | Meat | Liquid or drippings | | Meat | Liquid or drippings | Meat | Liquid or drippings | | Meat | Liquid or drippings | Meat | Liquid or drippings |
| | | *mg* | *mg* | *mg* | *Per cent* | *Per cent* | *mg* | *mg* | *mg* | *Per cent* | *Per cent* | *mg* | *mg* | *mg* | *Per cent* | *Per cent* |
| Pork lean 2" × 2" × 1" | Simmered | 1.97 | 0.67 | 0.42 | 34 | 21 | 1.19 | 0.51 | 0.23 | 43 | 19 | 22.57 | 5.59 | 6.44 | 25 | 28 |
| | boiled | | 0.42 | 0.34 | 21 | 17 | | 0.46 | 0.20 | 39 | 17 | | 5.90 | 4.17 | 26 | 18 |
| | braised | | 0.45 | 0.28 | 23 | 14 | | 0.48 | 0.13 | 40 | 11 | | 6.44 | 6.91 | 28 | 31 |
| | fried | | 0.60 | 0.06 | 30 | 3 | | 0.58 | 0.01 | 49 | 1 | | 7.23 | 0.67 | 32 | 3 |
| | broiled | | 0.90 | ------- | 46 | ------- | | 1.11 | ------- | 93 | ------- | | 9.43 | ------- | 42 | ------- |
| Pork shoulder with skin 2" × 2" × 1" | simmered | 1.56 | 0.33 | 0.44 | 21 | 28 | ** 0.63 | 0.27 | 0.31 | 43 | 49 | 14.45 | 3.33 | 5.79 | 23 | 40 |
| | boiled | | 0.48 | 0.51 | 31 | 33 | | 0.41 | 0.19 | 46 | 21 | | 3.80 | 3.18 | 26 | 22 |
| | braised | | 0.52 | 0.14 | 33 | 9 | 0.90 | 0.48 | 0.09 | 53 | 10 | | 4.41 | 1.75 | 30 | 12 |
| | fried | | 0.32 | 0.08 | 20 | 5 | | 0.51 | 0.02 | 57 | 2 | | 4.08 | 0.82 | 28 | 6 |
| | broiled | | 0.28 | ------- | 18 | ------- | | 0.32 | ------- | 36 | ------- | | 5.04 | ------- | 35 | ------- |
| Cubed pork 1/4" | simmered | 1.94 | 0.32 | 0.90 | 16 | 46 | 1.30 | 0.66 | 0.60 | 51 | 46 | 27.32 | 5.56 | 12.76 | 20 | 47 |
| | boiled | | 0.33 | 0.90 | 17 | 46 | | 0.57 | 0.48 | 44 | 37 | | 6.17 | 10.98 | 22 | 40 |
| | braised | | 0.36 | 0.28 | 18 | 14 | | 0.48 | 0.19 | 37 | 15 | | 7.88 | 4.96 | 29 | 18 |
| | fried | | 0.60 | *0.01 | 31 | *0.5 | | 0.52 | *0.02 | 40 | *2 | | 10.88 | 0.51 | 40 | 2 |
| | broiled | | *0.72 | ------- | *37 | ------- | | *0.64 | ------- | *49 | ------- | | *10.60 | ------- | *39 | ------- |
| Pork chop | simmered | 1.33 | 0.16 | 0.23 | 12 | 17 | 0.77 | 0.39 | 0.23 | 51 | 30 | 19.30 | 5.58 | 5.80 | 29 | 30 |
| | boiled | | 0.20 | 0.25 | 15 | 19 | | 0.26 | 0.22 | 34 | 28 | | 4.53 | 3.26 | 23 | 17 |
| | braised | | 0.22 | 0.08 | 16 | 6 | | 0.48 | 0.05 | 62 | 6 | | 6.53 | 1.96 | 34 | 10 |
| | fried | | 0.25 | 0.01 | 19 | 1 | | 0.27 | 0.03 | 35 | 4 | | 6.91 | 1.17 | 36 | 6 |
| | broiled | | 0.32 | ------- | 24 | ------- | | 0.31 | ------- | 40 | ------- | | 6.45 | ------- | 33 | ------- |
| Pork liver | simmered | 1.08 | 0.26 | 0.54 | 24 | 50 | 13.22 | 3.49 | 3.01 | 26 | 23 | 30.97 | 8.40 | 19.95 | 27 | 64 |
| | boiled | | 0.27 | 0.49 | 25 | 45 | | 5.43 | 2.00 | 41 | 15 | | 8.81 | 18.04 | 28 | 58 |
| | braised | | 0.24 | 0.52 | 22 | 48 | | 3.57 | 2.98 | 27 | 22 | | 8.02 | 11.87 | 26 | 38 |
| | fried | | 0.71 | 0.02 | 66 | 2 | | 5.59 | 0.10 | 42 | 1 | | 20.40 | 1.65 | 66 | 5 |
| | broiled | | 0.43 | ------- | 40 | ------- | | 4.75 | ------- | 36 | ------- | | 15.92 | ------- | 51 | ------- |
| Beef round | simmered | 0.16 | 0.02 | 0.07 | 12 | 44 | 0.48 | 0.13 | 0.23 | 27 | 48 | 29.41 | 6.72 | 18.28 | 23 | 62 |
| | boiled | | 0.05 | 0.08 | 31 | 50 | | 0.16 | 0.21 | 33 | 44 | | 7.09 | 19.08 | 24 | 65 |
| | braised | | 0.03 | 0.03 | 19 | 19 | | 0.25 | 0.12 | 52 | 25 | | 10.80 | 9.54 | 37 | 32 |
| | fried | | 0.05 | *0.003 | 31 | *2 | | 0.26 | 0.005 | 54 | 1 | | 16.63 | 0.93 | 56 | 3 |
| | broiled | | 0.04 | ------- | 25 | ------- | | 0.22 | ------- | 46 | ------- | | 17.43 | ------- | 59 | ------- |
| Beef sirloin | simmered | 0.37 | 0.03 | 0.10 | 8 | 27 | 0.81 | 0.23 | *0.47 | 28 | *58 | 27.07 | 6.25 | 15.75 | 23 | 58 |
| | boiled | | 0.04 | 0.07 | 11 | 19 | | 0.30 | 0.17 | 37 | 21 | | 7.78 | 13.34 | 29 | 49 |
| | braised | | 0.05 | 0.02 | 14 | 5 | | 0.46 | 0.19 | 57 | 23 | | 11.69 | 10.36 | 43 | 38 |
| | fried | | 0.06 | 0.003 | 16 | 1 | | 0.66 | 0.02 | 81 | 2 | | 19.17 | 0.68 | 71 | 2 |
| | broiled | | 0.12 | ------- | 32 | ------- | | 0.37 | ------- | 46 | ------- | | 14.17 | ------- | 52 | ------- |

* Two trials.

** Simmered sample only.

from the table, the figures varied considerably with a range for thiamine from 0.21 to 0.66 mg, 0.25 to 0.28 mg and 0.02 to 0.19 mg/100 gms for pork, liver and beef, respectively. The thiamine values for beef are within the lower limit of those reported by Waisman and Elvehjem, Booher and Hartzler and within the range reported by Cheldelin and Williams all as cited by Cover.(3)

Riboflavin values for raw samples ranged from 0.15 to 0.46 mg, 1.83 to 5.55 mg, and 0.08 to 0.29 mg/100 gms for pork, liver and beef, respectively. This is in agreement with the values reported by Cover,(3) which had an average of 1.3 μg/gm in beef.

Niacin values for raw samples ranged from 2.6 to 9.5 mg, 7.4 to 8.2 mg, and 5.3 to 8.0 mg/100 gms for pork, liver and beef, respectively. This is within the wider range reported by Dann and Handler of 31 to 32 μg/gm in beef ribs as cited by Cover(3) and agrees with the upper limit reported by Cover(3) of 39 to 60 μg/gm for rib of beef.

*Vitamin retention.*—Average vitamin retention of the different cuts of meat under various cooking procedures are shown in Table 4. B-vitamins are water soluble and vary in their stability reaction to heat; hence varying proportion were retained in cooked meat and liquid or drippings. Vitamin retention distribution between meat and liquid or dripping varied among the different kinds of vitamins under the various cooking procedures used. Considerable variations in the retention of water soluble vitamins may occur from one cooking method to another even though methods are standardized.(13) Moist-heat cooking methods leached out more vitamins than dry-heat methods. The results for the three vitamins under moist-heat cooking methods (particularly boiling and simmering) indicated that from ½ to ⅔ of the vitamin retained were transferred to the liquid. In the case of frying, amounts of vitamins transferred to the drippings were negligible. Drippings from broiling could not be collected; therefore, no figures were determined in this case. On the other hand, considering the vitamin retention in meat alone (as distinguished from that in liquid) broiling and frying obtained markedly higher retention percentage compared to those in braising, boiling, and simmering (except for riboflavin in pork).

Total vitamin retention was higher in moist-heat cooking than under dry-heat. In fact, except for slight variations, the

results indicated a consistent decrease of total vitamin retention from simmering through boiling, braising, frying, and broiling. Pork and beef stewed by simmering generally showed higher total vitamin retention as compared to boiling. In simmering, the average total retention percentages for thiamine, riboflavin and niacin were respectively: in pork—49, 83, 60; in pork liver—74, 49, 91; in beef—46, 80, 83. In the case of boiling, the following are the respective percentages: in pork—50, 66, 48; in pork liver—70, 56, 86; in beef—56, 68, 84.

Of the three vitamins, riboflavin showed the highest total retention in all cuts (except pork liver) in all cooking methods. In simmering riboflavin had an average total retention percentages of 83 and 80 for pork and beef, respectively. It may be assumed that no appreciable destruction of riboflavin took place during cooking. These high retentions were in line with the findings of several workers for cooked meat.(4, 6, 15) As regards thiamine it was observed that the average total retention in braised pork was 33 per cent and in braised beef 28 per cent. Tucker, et al.(15) reported 65 per cent thiamine retention in braised round beef; McIntire(9, 10) obtained 50 per cent thiamine retention in braised loin pork and 40 per cent in braised veal. As regards niacin, the average total retention obtained in this study were 48 per cent in braised pork and 75 per cent in braised beef. McIntire(9, 10) obtained about 65 per cent niacin retention in braised lamb cuts and veal, and 85 per cent in roast pork. Cover, et al.(3) obtained 75 to 79 per cent in rare and well done roast beef.

It was further noted in beef as well as in pork liver that retention of the B-vitamins in meat alone, i.e. excluding retention in liquid or drippings, was significantly greater under dry-heat cooking methods than under moist-heat.

## SUMMARY

The effects of various cooking procedures on the cooking losses and B-vitamin retention in pork and beef were determined. In pork, broiling and frying generally obtained higher percentage shrinkages than simmering, boiling, and braising. Differences were very marked and significant in the case of pork chop and shoulder. Moist-heat cooking methods produced higher percentage shrinkages on lean pork (41 to 52 per cent) and less percentage in pork chop and shoulder (23 to 39 per

cent). In the case of beef, the trend was reversed, although the difference were not significant. The percentage shrinkages by various cooking methods ranged from 42 to 48 per cent. Pork liver, however, showed a nearly constant shrinkage of 47 per cent in all cooking methods except in frying where shrinkage was less.

Conversion factors were also determined under various cooking methods.

As regards vitamin retention, moist-heat cooking methods (particularly boiling and simmering) leached out more vitamin. Figures from ½ to ⅔ of the vitamin retained were transferred to the cooking liquid. In the case of frying, the amounts of the vitamins transferred to the drippings were negligible. However, when total vitamin retention was considred, moist-heat cooking methods showed higher retention than dry-heat. Of the three vitamins, riboflavin showed the highest total retention in all cuts, except pork liver, for all cooking methods.

ACKNOWLEDGMENT

Acknowledgment is hereby given to Dr. Carmen LL. Intengan and Dr. Josefina Bulato-Jayme for their constructive criticisms and suggestions, and to Mrs. Isabel Concepcion-Abdon of the Food Research Laboratory for her full-hearted cooperation in the analyses of samples. The following conducted the various chemical analyses: Miss Aurea V. Lontoc, Mr. Jose G. Palad, Mrs. Emerina C. Eusebio, and Miss Natividad Santiago. Miss Stella F. Puzon rendered valuable assistance. The Technical Committee of the Food and Nutrition Research Center helped in the planning, evaluating, and editing of this report.

REFERENCES

1. Asp, E., I. Noble, and L. Gomez. Thiamine and riboflavin retention in veal. Jour. Am. Diet. Assoc. 29 (1953) 251.
2. Clark, R.R., and F. Duyne. Cooking losses, tenderness, palatability, thiamine and riboflavin content of beef as affected by roasting, pressure saucepan cooking and broiling. Food Res. 14 (1948) 221.
3. Cover, S., B.A. Mclaren, and P.B. Pearson. Retention of the B-vitamins in rare and well done beef. Journ. Nutr. 27 (1944) 363.
4. Cover, S., E. Dilsaver, and R. Hays. Retention of the B-vitamins in beef and lamb after stewing. Journ. Am. Diet. Assoc. 23 (1947) 865.
5. Hodson, A.C., and L.C. Norris. A fluorometric method for determining riboflavin content of foodstuffs. Journ. Biol. Chem. 162 (1946) 421.

6. HINMAN, W.F., R.E. TUCKER, L.M. JANS, and E.G. HALLIDAY. Excessively high riboflavin retention during braising of beef. Indus. Eng. Chem. Anal. Ed. (1946) 296.
7. LEVERTON, R.M., and G.V. ODELL. Nutritive value of cooked meat. Misc. Publ. No. 49 [Oklahoma Agricultural Experiment Station, Oklahoma State University (1958)].
8. LOWE, BELLE. Experimental Cookery. 4th ed. J. Wiley & Sons, Inc., New York Chapman & Hall, Ltd., London, 1955.
9. MCINTIRE, J.M., B.S. SCHWEIGERT, L.M. HENDERSON, and C.A. ELVEHJEM. The retention of vitamin in meat during cooking. Jour. Nutr. 25 (1943) 143.
10. MCINTIRE, J.M., B.S. SCHWEIGERT, and C.A. ELVEHJEM. The retention of vitamins in veal and lamb during cooking. Journ. Nutr. 26 (1943) 621.
11. GIVEN, META. Modern Encyclopedia of Cooking. J.G. Ferguson and Associates. Chicago, 1949.
12. MUNSELL, H.E., LOUIS O. WILLIAMS, LOUISE P. GUILD, CYNTHIA B. TROESCHER, GERTRUDE NIGHTINGALE, and ROBERT S. HARRIS. Composition of food plants of Central America. I. Hondurias, Food Res. 14 (1949) 144-164.
13. NOBLE, I., and L. GOMEZ. Thiamine retention in beef and veal heart. Journ. Am. Diet. Assoc. 27 (1951) 152.
14. Pharmacopoeia of the United States. 14th ed. and 1st USP XIV Suppl. Philadelpia, Mack Print. Co., 1950.
15. TUCKER, R.E., W.F., HINMAN, and E.G. HALLIDAY. The retention of thiamine and riboflavin in beef cuts during braising, frying and broiling. Journ. Am. Diet. Assoc. 22 (1946) 877.

# NUTRITIVE VALUE OF SOME FOODSTUFFS PROCESSED IN THE PHILIPPINES

By Jose Garcia Palad, Isabel C. Abdon, Aurea V. Lontoc, Leogarda B. Dimaunahan, Emerina C. Eusebio, and Natividad Santiago

*National Institute of Science and Technology, Manila*

(Received for publication, April 1, 1964.)

A foodstuff, before reaching the consumer's table, undergoes several processing steps not only to make it edible but also to preserve it as well as to improve its quality in terms of flavor, color and texture. These steps, though necessary, are known to affect its nutritive value directly or indirectly, depending on the nature of the food, the specific nutrient, the method, the temperature and length of time of processing and storage, as well as other environmental factors.

A review(11) of literature on the effect of processing on the nutritive value of foods has shown that vitamins and proteins are the nutrients most severely affected. Holman(12) thoroughly discusses the distribution of vitamins within the tissues of foodstuffs. Removal of tissues with relatively high or low vitamin content is reflected in the finished product. Moreover, any action which disrupts the cell walls liberates enzymes that help destroy the vitamins. The deleterious effect of roasting peanuts of 180°C on the biological value of its protein and the destruction of 25 per cent of both its riboflavin and pantothenic acid content have been reported by Buss and Goddard(4) and Dunn and Goddard.(7)

Evans, et al.(8) found that milk pasteurized by either the holder or the HTST (High Temperature-Short Time) process showed loss of thiamine. They also observed that the process of cheese manufacture caused no actual destruction of thiamine but progressive decrease was noted as the ripening period progressed. The vitamin losses in drying milk are very much the same as in pasteurization. Kon(20) reported 20 per cent loss of vitamin C, 10 per cent loss of thiamine and a slight deterioration in the biological value of the proteins in milk products upon drying.

Fatty fish are appreciably richer in vitamin A than lean fish but they are not valuable sources of this nutrient because of

the small amount present in the fish flesh. In general, processing appears to leave the vitamin A almost intact. Lunde(21) reported that when fish was smoked whole there was no loss of vitamin A, but when smoked as fillets, there was a slight loss of this vitamin with no serious destructive effect on its riboflavin and niacin content.

Factors causing considerable thiamine losses during baking are the final temperature, the time of heating and the bulk of product being baked. Average losses of 20 per cent thiamine for bread, 33 and 23 per cent for cake with and without raising agents, respectively, and 28 per cent for biscuit have been reported by Coppock, et al.(5) They concluded that thiamine destruction in baked products is mainly thermal and is affected by other factors only to a relatively small extent.

Prepared meats like Bologna sausage, frankfurters and Canadian bacon were found to contain about the same amounts of thiamine, riboflavin and nicotinic acid as fresh-muscle meats.(3, 23, 26) However, considerable variation in the retention of these vitamins during cooking was obtained depending on the cooking method, size and kind of meat as well as cooking time. Dunker, et al.(6) found no significant loss of biological value of the protein of ham after curing and smoking by different methods.

Intengan, et al.(13, 14, 15, 16, 17) have studied the composition of Philippine foods, but most of their results are for raw food items. The nutritional value of some Filipino recipes has been reported by Bautista, et al.(2) and Perez.(25) No other publications available on the nutritive value of locally processed foods is known.

This study was undertaken to collect data on the nutritive value of locally processed foods and some imported foods, which will augment the meager information given in the Food Composition Tables recommended for use in the Philippines.(9) All the processed foods reported in that table have been included and were re-analyzed whenever less than three samples were previously examined. The processed foods chosen for this study were those that are usually eaten with little or no re-cooking needed and do not include any canned foods except *tausi*, coffee, chocolate, guava jelly, and powdered milk. The imported foods included are those frequently found in the Filipino diet.

## EXPERIMENTAL PROCEDURE

Locally processed food samples were purchased from groceries, stores and/or public markets of Metropolitan Manila as well as from other parts of the Philippines. A sample of each food was obtained from at least three different places at different times and analyzed separately. The results obtained from the analysis of three or more samples were averaged.

The methods used for the preparation of stabilized samples and the analyses of fourteen nutrients; namely, moisture, fat, nitrogen, crude fiber, ash, calcium, phosphorus, iron, vitamin A, carotene, thiamine, riboflavin, niacin and ascorbic acid are essentially the same as those described by Intengan, et al.(13)

## DESCRIPTION OF FOODS STUDIED

For the benefit of those who are not familiar with the foods mentioned in this study, the following is a general description of those foods whose preparation is seldom found in foreign cookbooks or which has been modified and adapted for use with local materials. No attempt is made to give detailed descriptions or standard recipes, since the foods were analyzed as purchased and as there was no means of checking their procedures.

### CEREAL AND GRAIN PRODUCTS

SUMANG KAMOTENG KAHOY (*Cassava cake*).—Grated cassava tubers, grated coconut and sugar are mixed together and small portions of the mixture are rolled on rectangular pieces of banana leaves. The leaf is folded at both ends making a cylindrical roll which is about 7/8″ in diam. and 6″ in length. The rolls are tied in pairs with strips of dried leaf sheaths of abaca or banana. The *suman* is boiled in water for at least 2–½ hours.

CORN PRODUCTS—(1) *Binatog.*—This is boiled mature corn grains from which the seed coat has been removed. Mature corn grains are boiled with water and ordinary lime to loosen the seed coat. The seed coat is removed by pressing or rubbing against the bottom of a bamboo basket. After thorough washing and cleaning to remove the limy smell, the boiled grains are boiled again until soft. *Binatog* is eaten with grated coconut and salt or sugar.

(2) *Maha blangkang mais.*—This is prepared from a mixture of coconut milk, rice *galapong* (finely ground soaked rice), grated corn and sugar, which is cooked with constant stirring until thick. The cooked mixture is poured into molds and allowed to cool. It is served with *latik* and caramelized coconut meal. If yellow corn is used, a yellow *maha* is obtained.

(3) *Papkorn na maalat o matamis.*—Popcorn is prepared from a special variety of corn characterized by a hard corneous endosperm and small kernels which pop when heated in a closed container. Either salt or syrup is added to produce the salted or sweetened product.

BALAT NG LUMPIA (*lumpia wrapper*).—This is a white, thin, paperlike product made by steaming a batter of wheat flour. It is circular in shape, about 20 cm in diameter and is used for wrapping *lumpia,* a sauteed vegetable dish.

NOODLES—(1) *Bihon, tuyo.*—This is prepared by grinding previously soaked rice grains to a fine suspension in a millstone. After draining for 24 hours in linen bags, the rice dough is kneaded by hand or machine until homogeneous and plastic. The mass in then made into balls and pressed through a metal box provided with small round holes. The extruded filaments are dropped into a vessel of boiling water. The filaments are collected, arranged and spread on bamboo frames to dry under the sun. When dried, the product is ready for the market. It resembles macaroni except that it is white and smaller in diameter.

(2) *Macaroni.*—This is invariably manufactured from durum or common wheat flour. Egg proteins usually act as binder and impart the pleasing yellow color to the finished product. The samples used for analysis were produced locally.

(3) *Miki and misua.*—These products are also manufactured from wheat flour dough. For *miki* the dough is made saline with a 1- to 3-per cent salt solution. Alkali is added to make it golden yellow. The dough is flattened, cut into strips, boiled from 2 to 3 hours and dried under the sun. No alkali is added in the preparation of *misua.* The dough is stretched into fine long strings resembling vermicelli. These strings are dried under the sun.

(4) *Pideos* (*Vermicelli*).—This is prepared like the *bihon* except that glutinous rice is used and artificial coloring is added.

(5) *Sotanghon.*—This is prepared from mung bean flour by passing the dough through a collander shift. The extruded filaments are dropped into boiling water and are immediately cooled in cold water, washed and dried under the sun. It is white and crinkly. After cooking, the opaque, filaments become translucent.

RICE PRODUCTS—(1) *Ampaw na bigas.*—This cereal product is prepared by baking puffed rice with thick syrup and is usually sold at bus depots and railroad stations aside from public markets in the Philippines. *Ampaw* is sold in rectangular pieces, 2½" × 1" × ½" wrapped in cellophane or white paper.

(2) *Ampaw na pinipig.—Pinipig,* which is glutinous rice (*malagkit*) that has been roasted and pounded is used instead of puffed rice in its preparation. The samples used for analysis came from Laguna and Bulacan provinces.

(3) *Bibingkang galapong o malagkit.*—This is prepared from either ordinary or glutinous (*malagkit*) rice that has been soaked in water and ground in a stone mill. A batter is made from the ground rice (*galapong*) with sugar, margarine, baking powder, egg and thick coconut milk. It is baked in circular clay pans in a native oven that is heated with charcoal or coconut husk at the bottom and on top. An electric or gas oven can also be used. Slices of native cheese are placed on top of the mixture as soon as it begins to set. It is served with freshly grated coconut and hot tea or *salabat* (sweetened ginger root infusion).

(4) *Biko.*—Glutinous rice (*malagkit*) is boiled with coconut milk until the liquid is almost evaporated. Sugar is added and the mixture is stirred continuously until thick. It is served with grated coconut. *Pirurutong* (black rice) is often used to impart color to the preparation.

(5) *Kalamay.*—This is prepared from powdered glutinous rice (*malagkit*), coconut milk, sugar and water, which are boiled together until the mixture is thick and sticky. It is then poured while hot into pans lined with banana leaves and served with toasted coconut meal

(6) *Kutsinta.*—Rice flour is mixed with syrup (1 part sugar to 2 parts water) and lye solution prepared from an aqueous extract of firewood ashes. The mixture is then poured into small round molds and cooked by steaming for about 15 minutes. It is served with grated coconut.

(7) *Espasol.*—This is made from boiled *malagkit*, sugar, grated coconut, coconut milk and *anise* seeds which are cooked together until thick. Toasted rice flour is added and after thorough mixing it is passed through a meat grinder. Portions are shaped into rolls of about 2½" diam. and 6" length, rolled in toasted rice flour and cut into pieces of ½" thickness.

(8) *Palitaw.*—Glutinous rice (*malagkit*) is soaked and ground with a little water to form a stiff dough. Small balls of dough are flattened with the fingers into tonguelike shape and dropped in boiling water. When these float, they are removed, dropped in cold water and drained. *Palitaw* is served with grated coconut, sugar and toasted *liñga* (sesame-seeds). It is also known as *dila-dila.*

(9) *Pinipig.*—*Pinipig* is made by soaking freshly harvested glutinous palay in boiling water for 30 minutes. This is drained and roasted until the grains split and are thus partially freed from the hull. The soft grains are then pounded in a wooden mortar which gives to *pinipig* its flat appearance.

(10) *Puto bumbong.*—A stiff dough made from a mixture of glutinous rice and *pirurutong* is placed in small bamboo tubes and cooked by steaming in a native stove. It is served with grated coconut and refined or crude sugar (*pakaskas*).

(11) *Putong pula o puti.*—This is made from a thin batter of ground rice, salt, sugar and baking powder. The mixture is poured into molds and steamed until done. When brown sugar is used instead of white sugar, the product is brown in color. It is served with grated coconut. The samples used for analysis came from Polo, Bulacan Province.

(12) *Puto seko.*—This is made from ground rice flour and sugar, steamed, molded in various shapes and sizes and toasted in the oven. It is also prepared with grated coconut.

(13) *Sapin-sapin.*—This is prepared from a thick rice batter (*galapong*) with coconut milk, sugar, mashed ubi and powdered *anise.* It is cooked in three layers, one at a time and placed one over the other on a bamboo steamer lined with muslin cloth. The bottom layer is usually colored pink, the middle layer contains the *ubi*, while the top is white.

(14) *Suman sa ibos.*—Glutinous rice (*malagkit*) is soaked in water for 1 hour, then coconut milk and salt are added to it. The mixture is placed in wrappers made of young coconut leaves in the form of a cylindrical tube, 5½" in length and

1½" in diameter. The *suman* is boiled in water for one hour. It is served with sugar.

(15) *Suman sa lihiya.*—This is similar to *suman sa ibos* but contains lye extract instead of coconut milk. The lye extract is prepared by mixing firewood ashes with water and decanting the clear liquid that separates on top after standing. It is wrapped in green banana leaves which have been wilted, tied in pairs and boiled in water for 2 hours. It is served with grated coconut and sugar or *latik.*

(16) *Sumang maruwekos.*—This is prepared from ground glutinuous rice (*malagkit*) which has been previously soaked in water, coconut milk and sugar and cooked together until thick. The mixture is wrapped in wilted banana leaves just like the *suman sa lihiya* and tied in pairs. The *suman* is finally steamed for 30 minutes.

(17) *Tamales.*—This is a preparation of ground rice, coconut milk, sugar, salt, pepper and chopped peanuts cooked together. One half of the mixture is colored red with annatto extract (*Bixa orellana*) and 1 tablespoon of this is placed in the center of a banana leaf followed by 1 tablespoon of the uncolored mixture. Slices of pork, chicken, ham and hard cooked egg are placed on top before wrapping in the form of a square. The *tamales* is tied and cooked in boiling water for half an hour.

(18) *Tikoy.*—This is a Chinese product and its preparation is a trade secret. It is similar to *kalamay* but more sticky and has to be fried before serving with sugar. A similar preparation is being made in Quezon Province from glutinous rice flour, sugar, coconut milk, and peanut butter.

SIOPAW NA BABOY O MUNGGO.—This is like a meat roll but cooked by steaming instead of baking and is prepared from wheat dough. The contents may be either sweetened mungo beans or stewed pork. It is prepared by the Chinese.

MAHA BLANKANG UBI.—This is similar to the *maha blangkang mais* but yam (*ubi*) is used instead of corn. It is violet colored.

BAKERY PRODUCTS—(1) *Apa* (*wafer*).—This is prepared from a thin batter of flour, sugar and egg which is baked as thin circular sheets, and then rolled into cylinders. This is different from the wafer which is baked on a waffle mold with a cream filling.

(2) *Araro kukis.*—These cookies are prepared from arrowroot starch, butter, sugar, eggs and baking powder.

(3) *Bitso-bitso.*—This is prepared by the Chinese from a thick dough which is rolled, folded over and cut into strips. Two strips are twisted together and cooked by deep drying like doughnuts. It is rolled in sugar before serving.

(4) *Kamatsili.*—This is a cookielike preparation which is shaped like the *Kamatsili* [*Pithecolobium dulce* (Roxb.)] fruit, but is nearly straight and about 2 inches long.

(5) *Empanada (Meat pie).*—A stiff dough is prepared and rolled out until paper-thin. Then it is rolled to about ½" thick and cut into 1" pieces. Each piece is then flattened out with a rolling pin and 1½ teaspoon of meat or other kinds of filling is placed on the dough. The dough is folded over the filling and the edges pressed together after moistening with cold water. The *empanada* is cooked by deep frying and drained on paper before serving. Sometimes the dough covering the filling is made of thin strips which give a fluted appearance to the product. The meat filling is sauteed with ham, raisins, and other ingredients. A slice of hard cooked egg and pickle may be added to the cooked filling.

(6) *Ensaymada.*—This is similar to a sweet roll but is baked in the shape of a circular coil of various sizes. It is sprinkled with sugar after baking and a pat of butter or margarine is placed on top after cooling.

(7) *Gurgurya and pilipit.*—These are prepared from a stiff dough which is shaped into rods, folded and twisted together. They are cooked by deep frying and then glaced with sugar. The *gurgurya* is smaller, about 1" long and is seldom glaced with sugar, while the *pilipit* is about 4" long and is always glaced with sugar.

(8) *Hopya.*—This is a Chinese preparation that is very popular in the Philippines. It is made from dough which is stuffed with either sweetened mung bean or meat filling and baked. It is usually round or oval and the crust is made up of several thin layers.

(9) *Tinapay (Bread).*—*Pan de bonete* is shaped like a muffin and its crust is hard and crisp. *Pan de sal* is oval in shape, about 3" long and 1½" thick. *Pan de limon* is similar to a hamburger bun but smaller and does not contain any egg.

(10) *Pan de coco* is similar to *pan de limon* but is stuffed with sweetened coconut before baking.

(11) *Pasensiya.*—This is a round cookie about 1" in diameter and ¼" thick which is prepared from an ordinary cake batter but with less number of eggs.

(12) *Masa podrida.*—This is prepared from a dough made of grated coconut, sugar and flour mixed together and kneaded with egg yolk and sugar. The mixture is rolled out ¼" thick and cut with a biscuit cutter. Each piece is brushed with egg yolk and sprinkled with sugar before baking.

FRUIT AND VEGETABLE PRODUCTS

ARINA NG KAMOTENG KAHOY (*Cassava flour*).—Sliced cassava tuber (*Manihot esculenta*) is dried and ground in a mill to the desired fineness. The sample was obtained from the Bureau of Plant Industry, Manila.

SOYBEAN PRODUCTS—(1) *Taho and tokwa* (*Soybean cheese*).—Unpressed soybean curd is known as *taho* while the pressed curd is the *tokwa*. They are prepared from soybean milk extracted from water-soaked beans that have been ground in a stone mill. The milk is boiled and added to a gypsum solution to form the curd. For *taho* manufacture a small amount of the coagulating agent is used and the very soft but solid mass formed is allowed to settle down in a wooden container. For *tokwa* preparation, the coagulated mixture is strained through cheese cloth and the curd in the cheese cloth is pressed between 2 pieces of wooden boards to remove the remaining liquid. The compressed cakes are baked in a moderate oven until light brown. The inside of the cakes remain white. *Tokwa* is sold in cake form about 2½" square by ½" thick. *Taho* is almost tasteless and must be served with medium syrup.

(2) Soybean milk samples were purchased from a local manufacturer. Chocolate is added to the soybean milk to improve its flavor.

(3) *Miso* (*Soybean paste*) is prepared by pounding beans which have been boiled until suffiicently soft. It turns darker and becomes rancid after a few days.

(4) *Tahuri* is soybean curd which is prepared like *tokwa* and preserved in strong brine solution. It is sold in 8 cm cubes.

(5) *Tausi* (*Fermented salted bean*) is a fermented product prepared from black soybeans. It is brownish in color and

sold with the salty liquid in which the steamed beans were fermented.

(6) *Toyo* (*Soybean sauce*).—Boiled beans are dried in the sun, coated with flour and inoculated with the spores of *Aspergillus oryzæ* mold. The container is covered and allowed to stand at room temperature in a dark room for a few days. When the mixture becomes hot and hardens it should be broken up to prevent spoiling. When the flour and bean culture mixture no longer becomes hot after breaking and heaping it, 10 per cent saline solution previously inoculated with Fleichmann yeast or *tuba* (fermented palm sap), is added and the enzyme fermentation continued in the sun for at least 4 months. Previously boiled brine is added before and during the harvest of the sauce or dark brown liquid. The sauce is boiled, filtered and processed. The residue may be used for *tausi* while in compact form or as *tahuri* when finally macerated.

### MEAT, FISH, AND POULTRY PRODUCTS

MEAT PRODUCTS.—(1) *Kekiyam* (*Meat loaf*) is ground pork, mixed with egg, pepper, flour and soy sauce, rolled in leaf lard and cooked by steaming. It is sliced, sprinkled with flour and fried before serving.

(2) *Longganisang baboy at baka* (*Native sausage*).—This is prepared from lean beef and/or pork or their trimmings and cubed fat mixed with potassium nitrate, vinegar, wine, salt, sugar, and spices. The mixture is allowed to cure in the refrigerator for 5 days before stuffing in hog casings and linking. The product is perishable and must be kept under refrigeration.

(3) *Longganisang Makaw* (*Canton type sausage*).—This is a partially dried sausage whereby about 10 per cent of the original moisture has been evaporated. It is prepared from lean pork or pork trimmings and fat mixed with potassium nitrate, salt, sugar, rum, and red coloring. The mixture is placed in the refrigerator to cure for about 3 days before stuffing in hog casings and linking. The sausages are then dried until a hardened product is obtained.

(4) *Sitsarong baboy* (*Pig's crackling*).—This is made from the skin of pork. It is brittle, dry and without fat. The skin is boiled until soft and allowed to drip several hours before dipping it in hot lard. It is used as garnishing in

*pancit luglog*, as appetizer in cocktail parties, as an ingredient in stewed vegetables, and as a viand.

(5) *Tapa* is dried salted meat of any kind which has been cut into slices.

FISH AND POULTRY PRODUCTS

(1) *Bagoong* (*Salted and fermented shrimp, fish and shellfish*).—This is obtained from the fermentation of small salted fishes or shrimps packed in earthen pots or jars. Several kinds of *bagoong* were analyzed; namely, *bagoong alamang* (small shrimps); *bagoong hipon* (gobyfry); *bagoong isda* (anchovy); *bagoong padas* (siganid fry); and *bagoong talaba* (oyster). *Bagoong isda* came from Balayan, Batangas Province, and *bagoong hipon*, from Sta. Lucia, Ilocos Sur Province.

(2) *Daing* is dried salted fish of any kind and size. The fish is cut along the center of the dorsal side lengthwise, cleaned, salted and dried under the sun.

(3) *Fish balls*.—These are prepard from ground fish meat mixed with fish broth, milk, flour, *patis* and spices. The paste is made into balls about 1″ in diameter and cooked either by steaming or drying. It is used as an ingredient in *pancit* and other Filipino dishes.

(4) *Patis* (*Fish sauce*).—This product is the liquid obtained from the fermentation of small salted fishes and shrimps during the preparation of *bagoong*. A high grade *patis* should contain 10 per cent protein. It is used for seasoning many Filipino dishes and as sauce for boiled fish, meat or chicken. The sample came from Malabon, Rizal Province.

(5) *Tuyo* is salted whole fish, preferably small ones ranging from 3″ to 6″ long, which has been dried under the sun without removing the internal organs. The *tuyo* of the following fish were analyzed: *ayungin, sapsap*, and *tunsoy*. The *ayunging tuyo* came from Cardona, Rizal Province.

(6) *Tinapa* (*Smoked fish*).—Large sardines 4 to 8″ long are washed thoroughly and soaked in brine for a few minutes or hours, depending on the size of the fish. Then they are dried under the sun until firm prior to smoking. Smoke is produced by burning sawdust of *lauan* or other nonresinous wood in a charcoal fire under a tall pot having a small hole in the bottom and an open top. One or more trays of fish are placed over the pot with a tightly wooven bamboo basket placed on top as cover. Smoking is done for 1 to 7 hours depending upon the smoke desired and the size of the fish. The fish

should be turned several times during the smoking. The product will keep from 2 to 4 weeks without spoiling.

EGGS—(1) *Balut* is fertilized duck's egg that has been incubated from 18 to 20 days. A home-made incubator consists of a cylindrical bamboo basket about 50 cm in diameter and opened at both ends. These baskets are arranged in pairs inside a bamboo or wooden frame. The spaces in between are filled with rice hull to serve as insulation. A bag of heated hull is placed at the bottom of the basket. An abaca or *sinamay* bag containing the eggs is placed on top of the heated rice hull. The entire box is covered with 2 to 4 layers of cotton flannel or burlap sheets and the floor of the hatchery is covered with a layer of rice hull 2 to 4″ deep. The temperature throughout the incubation period is maintained at 39° C by heating the rice hull every morning and afternoon in a large iron vat. The eggs are turned morning and afternoon when the bags of rice hull are removed to heat their contents. Testing for fertile eggs is done by candling on the 5th, 13th and 14th days of incubation. After 18 days the fertile eggs are boiled. The samples came from Pateros, Rizal Province.

(2) *Penoy* is incubated duck's egg in which the germ failed to develop further after 13 or 14 days' of incubation due to low vitality. The egg is removed from the incubator and boiled.

(3) *Itlog na maalat (Salted egg)*.—Duck's eggs are packed in a mixture of four parts sticky clay and 1 part salt and allowed to remain in this mixture from 10 to 14 days. After this period an egg is tested by boiling and if not salty enough the curing period is prolonged. The hard cooked eggs are painted with a red dye to identify them in the market.

(4) *Century egg*.—This is also prepared from duck's eggs. The eggs are covered with a mixture of tea infusion, pine wood, coal, charcoal ashes and lime. They are placed in an earthern jar lined with earth or rice husk and allowed to cure for 100 days or more. The product is odorous with a gelatinous brown egg albumen and a dark gray yolk. It is used as an appetizer for Chinese dinners.

### MILK AND MILK PRODUCTS

(1) *Cottage cheese* is prepared by fermenting skim milk for 4 days to develop lactic acid for complete curdling of the milk. The curdled milk is boiled to about 50°C to recover the albumin

and for the separation of whey from the coagulated mass. A little salt is added to improve the flavor and preserve the cheese. There should be enough whey left in the curd after draining to render it neither too wet nor too dry. The sample was obtained from a local dairy plant.

(2) *Kesong puti* (*Native cheese*).—This is prepared from carabao's milk by coagulation with rennet enzyme or vinegar and heat. When the curds have set, refined salt is added to taste and after thorough mixing they are placed in molds and allowed to harden. The whey is drained off and the cheese is wrapped in banana leaves. The product is white, soft and tasty.

(3) *Polboron* is prepared from toasted flour mixed with sugar, powdered milk, butter or margarine and flavoring. The mixture is molded and wrapped in colored tissue paper.

SUGAR PRODUCTS

(1) *Banana chips or crackers*.—These are prepared from the *saba* variety. Thin slices of banana are partially dried, soaked in syrup and dried again until crisp to produce banana chips. Thicker slices are used for banana crackers. The crackers came from Iloilo City.

(2) *Matamis na rimas* (*Breadfruit candy*).—Breadfruit is boiled in water, peeled and sliced. It is soaked overnight in thin syrup and the syruping is continued for several days, gradually increasing the syrup concentration daily. The product is glaced, if desired before drying.

(3) *Matamis na bao* (*Coco honey*).—This is prepared from coconut milk mixed with brown sugar and *kalamansi* (*Citrus microcarpa* Bunge) juice. The mixture is cooked with constant stirring until it falls in a mass when dropped from a spoon. It is filled in sterilized jars while hot and covered tightly. The sample was obtained from Sariaya, Quezon Province.

(4) *Guava jelly* is prepared from mature but unripe guavas. The fruits are washed, blanched, sliced and boiled in a little water until soft. The mixture is placed in a bag and allowed to drip. Sugar and citric or tartaric acid are added and the mixture is boiled and skimmed until the jellying point is reached. The jelly is poured into sterilized containers while hot and after cooling, melted paraffin is poured on top of the jelly before sealing.

(5) *Karamelo* is made from refined sugar and a little water. The mixture is molded into 2″ × 2″ square slabs and dried. It is eaten like candy or used as a substitute for sugar in certain food preparations.

(6) *Lohuwa.*—This is manufactured by the Chinese from rice, peanuts or sesame seeds and its preparation is a trade secret. It is crisp, hollow inside and about 4″ long and 1″ wide.

(7) *Pastilyas de leche* (*Milk fudge*).—Fresh carabao milk is heated with continuous stirring over a low fire until ¾ of its original volume has evaporated. Then sugar and lemon rind are added and cooking is continued with constant stirring until a soft ball is formed. The paste is poured on a sugared board, cut into 2″×½″ pieces, rolled in sugar and wrapped in tissue paper. When yam (*ubi*) is added to the milk and sugar the product is yam fudge, (*ubido, ubidolse*).

(8) *Nata de coco.*—*Nata* is the thick mucilaginous film found on the surface of an acidified liquid containing sugar and other food constituents necessary for the growth of the nata-producing microorganism. Fresh coconut water is strained, acidified with glacial acetic acid and sugar added to make a 15 per cent sugar solution. The starter is added to the mash and the mixture is allowed to ferment for 10 to 14 days. The *nata* is harvested and processed by soaking, washing and cutting into desired size. Washing of cut nata is continued until the acid taste is no longer detected. Then the *nata* is cooked with sugar, packed in bottles and sterilized. *Nata* can also be prepared from coconut skim milk incorporated with coconut water.

(9) *Peanut crakers.*—This is prepared from selected shelled peanuts which have been coated with a thin batter of soybean flour, wheat flour, salt and egg white. The peanuts are arranged one by one on a baking pan, then toasted in the oven until brown.

(10) *Bibingkang gabi* (*Taro cake*).—This is prepared from ground boiled taro, mixed with sugar and coconut milk. The mixture is cooked with constant stirring until thick like paste. Then it is poured on clean wilted banana leaves. When cool, it is sliced into 2″×2¼″ pieces and served with *latik.*

(11) *Turon.*—This is prepared from peanut or pilinut. The nuts are ground and mixed with butter, mik, sugar and egg yolk. The mixture is cooked over a low fire until the paste

is quite dry. The paste is poured on a board, cooled and cut into rectangular pieces.

(12) *Tsampoy na sampalok* (*Tamarind candy*).—Tamarind fruits are peeled and mashed with a little salt and sugar. They are cooked with flour until thick. After cooking the mixture is made into balls containing at least one seed, rolled in sugar and packed in paper or cellophane bags. The sample came from Pasig, Rizal Province.

(13) *Kending kundol* (*Waxgourd candy*).—Waxgourd fruit is peeled and sliced. It is soaked in calcium oxide (lime) solution overnight, rinsed and boiled gently with syrup. The slices are glaced before drying.

MISCELLANEOUS

(1) *Sarsang saging* (*Banana sauce*).—This is prepared from *saba* banana, sugar, vinegar and spices cooked together. Food coloring is added to simulate the color of tomato sauce.

(2) *Gulaman.*—This may be prepared by sun drying and bleaching the thallus of the algæ, or by making a jelly of the seaweeds and allowing the water to freeze out. The residue is cut into thin strips and dried thoroughly. The red color is produced by incorporating a red dye in the agar.

(3) *Tuba* (*Fermented palm sap*).—*Tuba* is fermented coconut sap which is obtained by tapping the flower spathe of the coconut tree and collecting the juice that oozes out. This is fermented for a few hours only. The sample came from Silang, Cavite Province.

## RESULTS AND DISCUSSION

Two hundred and eighteen locally processed foods were analyzed in this study. The foods have been grouped into cereal and grain products; fruit and vegetable products; meat, fish and poultry products; milk and milk products; sugar products and miscellaneous. The results of the proximate, mineral and vitamin analyses of these foods are presented.

Table 1 shows the nutritive value of 96 cereal and grain products. Most of the foods in this group are bakery products and preparations from rice, corn and cassava which are commonly used as snack items or as desserts. The chief contribution of these products is food energy (calories). Protein values are generally below 5 per cent and those foods with more than 10 per cent protein are not eaten in sufficient quantities to appreciably increase the protein content of the

diet. The fat content of bakery products is usually above 10 per cent because of the shortening used in their preparation. Except for butter cookies, there are no excellent sources of calcium and phosphorus in this group; almost all goods are fair or poor sources of iron. The yellow corn products contain some vitamin A in the form of carotene. The use of enriched flour for baking makes some of the bakery products good sources of thiamine and niacin. However, thiamine destruction has been found to increase with increased exposure to heat(27) and there is greater loss of thiamine in bread than in rolls. Ascorbic acid is negligible in the foods of this group.

The results of the analysis of 17 fruit and vegetable products are given in Table 2. Peanuts, cashew and some soybean products like *tahuri, tausi, miso* and *tokwa* have high protein contents that may partially contribute to the dietary intake of this nutrient. These soybean proucts are also good sources of phosphorus while peanuts are excellent sources of phosphorus, thiamine and niacin. Only prunes and *toyo* are good sources of iron in this group. *Mansanitas* is a good source of ascorbic acid.

Table 3 gives the food value of 55 meat, fish and poultry products. The majority of the foods in this group are dried, salted and smoked fish which are very common items in the average Filipino diet. Their main contributions to the diet are protein, minerals and niacin. The results essentially substantiate the observation of Adriano and Guzman(1) on the high calcium and phosphosus content of local fish and fish products. The meat products and eggs likewise contribute to the protein intake but their minerals, except for phosphorus of eggs, are lower than those of fish products. Ham and *tapa* are excellent sources of thiamine.

Tho nutritive values of 10 milk and milk products are given in Table 4. These foods contribute protein, calcium and riboflavin, but are very expensive and beyond the reach of the low-income groups. The calcium and phosphorus contents of goat's milk are lower than those of cow's and carabao's milk, but its iron content is ten times higher. The fat of carabao's milk is very high, therefore it is not recommended for infant feeding. Native cheese is a better source of iron than cottage and kraft cheese. Chocolait and choco-malt are inferior to powdered cow's milk in protein, minerals, (except iron) and vitamins. Ascorbic acid is not present in the foods of this group.

Table 5 shows the proximate, mineral and vitamin contents of 27 sugar products which are mainly used for snacks or dessert. As in the cereal and grain products the calorie content of these foods is their main contribution to the diet. Products containing peanuts have high protein, fat, phosphorus and thiamine contents, and if eaten in great quantities they may serve as good sources of these nutrients.

Thirteen other food items are given in Table 6. They have no outstanding food values and are mainly used for seasoning and as beverages. The analyses of dried cocoa and coffee powder and dried tea leaves are reported in this study; therefore their nutritive values for protein, fat (cocoa) and minerals are not significantly high when prepared as beverages. *Gulaman* contains 488 mg per cent calcium, but this is also insignificant because of the quantity that is usually eaten.

## SUMMARY

The proximate, mineral and vitamin contents of 218 locally processed foods are presented. These foods included 96 cereal and grain products, 17 fruit and vegetable products, 55 meat fish and poultry products, 10 milk and milk products, 27 sugar products, and 13 miscellaneous products.

Peanut and soybean products, meat, fish and poultry products, milk and milk products are among the processed foods which can be considered as good or excellent sources of protein, minerals and vitamins.

## ACKNOWLEDGMENT

The authors wish to extend their sincere appreciation to Dr. Conrado R. Pascual, Research Director and Dr. Carmen Ll. Intengan, Assistant Director, Food and Nutrition Research Center for this continuous guidance and inspiration; to Dr. Jose Villa Panganiban, Director of the Institute of National Language, for going over the Filipino and English names of processed foods reported in this study; to Mr. Angustin F. Umali, Ichthyologist of the National Museum, for checking the scientific names of the fish products; to the staff of the Nutrition Research Laboratory, Food and Nutrition Research Center, for their help in the analysis of some of the foods; and to the members of the Food and Nutrition Research Center Technical Committee for editing this paper.

Acknowledgment is also made to the staff of the Food Research Laboratory who in one way or another have helped in the preparation of this paper.

## REFERENCES


1. ADRIANO, F. T., and M. S. GUZMAN. The phosphorus and calcium content of some Philippine food products. Phil. Agric. 20 (1932) 43.
2. BAUTISTA, A. P., V. Q. ALABASTRO, and M. CAEDO. The acceptability and nutritional value of some Filipino recipes. Phil. Jour. Home Econ. 10 (1950) 14.
3. BEUK, J. F., J. F. FRIED, and E. E. RICE. Nutritive values of sausage and other table ready meat as affected by processing. Food Res. 15 (1950) 302–307.
4. BUSS, L. W., and V. R. GODDARD. Effect of heat upon the nutritive values of peanut. I. Protein quality. Food Res. 13 (1948) 506.
5. COPPOCK, J. B., B. R. CARPENTER, and R. A. KNIGHT. Cereal product fortification: The B-vitamins with special references to the thiamine losses in baked products. Jour. Sci. Food Agric. 7 (1956) 457–461.
6. DUNKER, C. F., M. BERMAN, G. G. SNIDER, and H. S. TUBIASH. Quality and nutritive properties of different types of commercially cured hams. III. Vitamin content, biological value of the protein and bacteriology. Food Tech. 7 (1953) 288–291.
7. DUNN, K. R., and V. R. GODDARD. Effect of heat upon the nutritive values of peanuts. II. Riboflavin and pantothenic acid contents. Food Res. 13 (1948) 512–517.
8. EVANS, E. V., O. R. IRVINE, and L. R. BRYANT. The retention of nutrients in cheese making. IV. Thiamine in cheddar cheese made from raw and pasteurized milk. Jour. Nutr. 32 (1946) 227–237.
9. Food composition tables—Proximate, minerals and vitamins. Recommended for use in the Philippines. Institute of Nutrition Handbook I, Revised 1957, Manila.
10. A Handbook of Philippine Agriculture. College of Agriculture, Univ. of the Phil. (1939) 803 pp.
11. HARRIS, R. S., and H. VON LOESECKE, editors. Nutritional Evaluation of Food Processing. John Wiley and Sons, Inc., New York (1960) xviii + 612 pp.
12. HOLMAN, W. I. Distribution of vitamins in friuts and vegetables. Nutr. Abst. Rev. 26 (1956) 277.
13. INTENGAN, C. LL., L. G. ALEJO, I. CONCEPCION, C. YAPTINCHAY, V. L. POBRE, R. D. SALUD, and J. MANALO. Composition of Philippine foods. I. Philip. Jour. Sci. 82 (1953) 227–252.
14. INTENGAN, C. LL., I. CONCEPCION, R. D. SALUD, J. MANALO, I. DEL ROSARIO, R. GOMEZ, V. ARZAGA, and L. G. ALEJO. Composition of Philippine foods. II. Philip. Jour. Sci. 83 (1954) 187–216.
15. INTENGAN, C. LL., L. G. ALEJO, V. A. CORPUS, R. D. SALUD, I. DEL ROSARIO, R. GOMEZ, J. HENSON, and I. CONCEPCION. Composition of Philippine foods. III. Philip. Jour. Sci. 84 (1955) 263–273.
16. INTENGAN, C. LL., I. CONCEPCION, L. G. ALEJO, V. A. CORPUS, R. D. SALUD, I. DEL ROSARIO, R. GOMEZ, and J. HENSON. Composition of Philippine foods. IV. Philip. Jour. Sci. 84 (1955) 343–363.
17. INTENGAN, C. LL., L. G. ALEJO, I. CONCEPCION, V. A. CORPUS, R. D. SALUD, I. DEL ROSARIO, R. GOMEZ, and J. HENSON. Composition of Philippine foods. V. Philip. Jour. Sci. 85 (1956) 203–213.

18. JACOBS, M. B., editor. The Chemistry and Technology of Food and Food Products. 2nd ed. Interscience Publishers, Inc., New York 2 (1951) xxvi + 1769 pp.
19. Kitchen Tested Recipes. 3rd. ed. Food and Nutrition Research Center, National Media Prod. Center (1963).
20. KON, S. K. The chemical composition and nutritive value of milk and milk products. Chem. Ind. 62 (1943) 478–481.
21. LUNDE, FISCHWAREN u. Feinkost Industr., 1937, pts. 8/9 cited by Lovern, J. A. The nation's food. VI. Fish as food. 3. The vitamin and mineral content of fish. Chem. Ind. 62 (1943) 328–330.
22. MENDOZA, J. M. Philippine Foods, Their Processing and Manufacture. Manila, Phil. (1961) 421 pp.
23. MCINTIRE, J. M., B. S. SCHWEIGERT, E. J. HERBERT, and C. A. ELVEHJEM. Vitamin content of variety meats. Jour. Nutr. 28 (1944) 35–40.
24. PEREZ, E. D. Recipes of the Philippines. 2nd ed. Capitol Publ. House, Inc., Manila, Phil. (1954) 120 pp.
25. PEREZ, P. Everyday Foods in the Philippines. Banawe Publ. Co., Inc. (1953) 286 pp.
26. SCHWEIGRT, B. S., B. A. BENNETT, M. MARQUETTE, H. E. SCHEID, and B. H. MCBRIDE. Thiamine, riboflavin and niacin content of processed meats. Food Res. 17 (1952) 56–59.
27. ZAEHRINGER, M. V., and C. J. PERSONIUS. Thiamine retention in bread and rolls baked to different degrees of browness. Cereal Chem. 26 (1949) 384–392.

031610——4

TABLE 1.—*Cereal and grain products.*

| Item | Local name | English name | Representative values for 100 gm edible portion | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Calories | Moisture | Protein | Fat | Ash | Carbohydrate | Crude fiber | Calcium | Phosphorus | Iron | Vitamin A | Thiamine | Riboflavin | Niacin | Ascorbic acid |
| | | | *gm* | *gm* | *gm* | *gm* | *gm* | *gm* | *gm* | *mg* | *mg* | *mg* | IU | *mg* | *mg* | *mg* | *mg* |
| 1 | Ampaw na bigas | Sweetened puffed rice | 385 | 5.6 | 4.5 | 2.1 | 0.7 | 87.1 | 0.5 | 26 | 80 | 2.5 | ..... | 0.01 | 0.14 | 1.6 | ..... |
| 2 | Ampaw na pinipig | Sweetened puffed rice flakes | 392 | 3.3 | 3.1 | 1.6 | 0.7 | 91.3 | 0.7 | 23 | 127 | 7.1 | ..... | traces | 0.04 | 2.0 | ..... |
| 3 | Balat ng lumpiya | Lumpia wrapper | 316 | 20.2 | 10.6 | 0.5 | 1.5 | 67.2 | ..... | 41 | 90 | 5.0 | ..... | 0.23 | 0.06 | 2.8 | ..... |
| 4 | Bibingkang galapong | Rice cake | 234 | 41.5 | 3.6 | 0.9 | 1.1 | 52.9 | ..... | 96 | 135 | 5.3 | ..... | 0.12 | 0.05 | 0.6 | ..... |
| 5 | Bibingkang galapong na may keso't kinudkod na niyog | Rice cake with cheese and grated coconut | 223 | 45.6 | 2.8 | 2.6 | 1.8 | 47.2 | 1.3 | 71 | 73 | 5.1 | ..... | 0.09 | 0.06 | 0.6 | ..... |
| 6 | Bibingkang malagkit | Glutinous rice cake | 257 | 36.8 | 2.8 | 1.1 | 0.4 | 58.9 | 0.5 | 13 | 59 | 1.5 | ..... | 0.03 | 0.01 | 1.1 | ..... |
| 7 | Bihon | Rice noodles | 360 | 12.9 | 4.7 | 0.1 | 0.2 | 82.1 | 0.2 | 6 | 35 | 1.8 | ..... | 0 | 0.01 | 0.1 | ..... |
| 8 | Bihong luto | Cooked rice noodles | 99 | 76.0 | 1.3 | 0 | 0.1 | 22.6 | 0 | 4 | 10 | 0.6 | ..... | 0 | 0 | 0 | ..... |
| 9 | Biko | Glutinous rice preparation | 252 | 37.9 | 2.2 | 0.9 | 0.3 | 58.7 | 0.7 | 12 | 35 | 1.3 | ..... | 0.03 | 0.01 | 0.6 | ..... |
| 10 | Bikong malagkit na may kinudkod na niyog | Glutinous rice preparation with grated coconut | 246 | 40.0 | 3.3 | 1.6 | 0.4 | 54.7 | 1.7 | 14 | 53 | 2.4 | ..... | 0.02 | 0.02 | 0.6 | ..... |
| 11 | Bikong may pirurutong | Glutinous rice preparation with black rice | 227 | 43.6 | 2.6 | 0.4 | 0.2 | 53.2 | 1.7 | 14 | 33 | 1.5 | ..... | 0.02 | 0.04 | 0.5 | ..... |
| 12 | Binatog | Hominy | 111 | 73.8 | 3.3 | 2.6 | 0.4 | 19.9 | 0.6 | 17 | 85 | 1.0 | 250 | 0.05 | 0.03 | 0.4 | 1 |
| 13 | Kalamay na malagkit na may latik | Glutinous rice preparation with coconut syrup | 208 | 48.2 | 2.7 | 0.4 | 0.3 | 48.4 | 1.0 | 10 | 32 | 2.6 | ..... | 0.01 | 0.01 | 0.3 | ..... |
| 14 | Kutsinta | Rice preparation | 168 | 58.6 | 1.4 | 0.9 | 0.5 | 38.6 | ..... | 11 | 10 | 1.6 | ..... | trace | 0.01 | 0.2 | ..... |
| 15 | Kutsintang may niyog | Rice preparation with grated coconut | 158 | 64.0 | 1.6 | 3.2 | 0.5 | 30.7 | ..... | 9 | 41 | 4.6 | ..... | 0.01 | 0.02 | 0.3 | ..... |
| 16 | Espasol | Glutinous rice product | 312 | 25.8 | 4.0 | 3.6 | 0.8 | 65.8 | 5.6 | 19 | 114 | 3.2 | ..... | 0.07 | 0.04 | 1.1 | ..... |
| 17 | Makaroni | Macaroni | 361 | 11.4 | 14.3 | 0.3 | 0.6 | 73.4 | 0.2 | 30 | 113 | 3.1 | ..... | 0.57 | 0.25 | 4.4 | ..... |
| 18 | Maha blangkang mais | White corn flour preparation | 149 | 64.0 | 1.3 | 1.1 | 0.2 | 33.4 | 0.7 | 6 | 21 | 1.7 | ..... | 0.01 | 0.01 | 0.2 | ..... |
| 19 | Maha blangkang may kinudkod na niyog | White corn flour preparation with grated coconut | 187 | 54.8 | 1.0 | 1.4 | 0.2 | 42.6 | 1.3 | 15 | 33 | 1.2 | ..... | 0.01 | 0.01 | 0.1 | ..... |
| 20 | Maha blangkang may ubi | White corn flour preparation with yam | 209 | 48.5 | 1.1 | 1.2 | 0.7 | 48.5 | 0.7 | 19 | 36 | ..... | ..... | ..... | 0.01 | 0.3 | ..... |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | Maha blankang mais | Yellow corn preparation | 128 | 69.8 | 1.1 | 1.6 | 0.2 | 27.3 | 1.4 | 32 | 30 | 1.2 | 123 | 0.01 | 0.04 | 0.1 | ------ |
| 22 | Maha blankang mais may kinudkod na niyog | Yellow corn preparation with grated coconut | 149 | 63.8 | 1.8 | 1.0 | 0.2 | 33.2 | 0.9 | 17 | 29 | 1.9 | 198 | 0.03 | 0.03 | 0.3 | ------ |
| 23 | Maha blangkang ubi | Yam preparation | 187 | 53.5 | 1.2 | 0.8 | 0.7 | 43.8 | 0.6 | 24 | 51 | 3.1 | ------ | 0.04 | 0.03 | 0.3 | ------ |
| 24 | Maha blangkang ubing may kinudkod na niyog | Yam preparation with grated coconut | 191 | 53.0 | 1.7 | 1.2 | 0.7 | 43.4 | 1.0 | 18 | 47 | 2.4 | ------ | 0.05 | 0.02 | 0.3 | ------ |
| 25 | Miki | Wheat noodles | 337 | 28.6 | 7.9 | 11.8 | 1.7 | 50.0 | ------ | 49 | 47 | 2.8 | ------ | 0.10 | 0.01 | 1.6 | 0 |
| 26 | Miking luto | Cooked wheat noodles | 122 | 75.9 | 3.2 | 5.4 | 0.4 | 15.1 | ------ | 21 | 21 | 0.5 | ------ | 0.03 | 0.04 | 0.5 | ------ |
| 27 | Misuwa | Wheat noodles | 350 | 11.3 | 12.1 | 0.1 | 3.7 | 72.8 | ------ | 55 | 74 | 2.1 | ------ | 0.20 | 0.03 | 3.2 | 0 |
| 28 | Misuwang luto | Cooked wheat noodles | 84 | 78.2 | 3.3 | 0.1 | 0.9 | 17.5 | ------ | 29 | 23 | 1.0 | ------ | 0.08 | 0.02 | 0.8 | ------ |
| 29 | Palitaw | Glutinous rice preparation | 208 | 51.1 | 2.6 | 2.8 | 0.3 | 43.2 | ------ | 18 | 45 | 3.2 | ------ | 0.04 | 0.02 | 0.7 | ------ |
| 30 | Palitaw na may niyog at asukal | Glutinous rice preparation w/grated coconut and sugar | 211 | 52.6 | 2.6 | 4.5 | 0.3 | 40.0 | ------ | 17 | 44 | 3.3 | ------ | 0.04 | 0.02 | 0.7 | ------ |
| 31 | Pideos | Vermicelli | 366 | 10.6 | 10.2 | 0.3 | 1.0 | 77.9 | 0.1 | 19 | 70 | 2.1 | ------ | 0.30 | 0.12 | 2.7 | ------ |
| 32 | Pinipig | Glutinous rice flakes | 349 | 15.3 | 5.0 | 1.0 | 1.4 | 77.3 | 0.9 | 17 | 224 | 2.0 | 20 | 0.24 | 0.05 | 4.3 | ------ |
| 33 | Papkorng maalat, binusang mais na maalat | Salted popcorn | 471 | 3.8 | 6.7 | 18.6 | 1.7 | 69.2 | 1.1 | 33 | 174 | 0.3 | ------ | 0.01 | 0.05 | 1.9 | ------ |
| 34 | Papkorng matamis | Sweet popcorn | 443 | 2.3 | 4.0 | 11.0 | 0.8 | 81.9 | 1.4 | 27 | 113 | 2.4 | ------ | 0.03 | 0.05 | 0.9 | ------ |
| 35 | Puto bumbong | Rice preparation | 251 | 38.5 | 3.5 | 1.3 | 0.3 | 56.4 | ------ | 13 | 44 | 2.3 | ------ | 0.03 | 0.01 | 0.5 | ------ |
| 36 | Puto pula | Rice preparation with red coloring | 206 | 48.1 | 2.0 | 0.1 | 0.5 | 49.3 | 0.2 | 5 | 23 | 2.9 | ------ | traces | 0.01 | 0.1 | ------ |
| 37 | Puto puti | Rice preparation without coloring | 216 | 45.8 | 2.8 | 0.2 | 0.4 | 50.8 | ------ | 6 | 35 | 2.7 | ------ | 0.01 | 0.01 | 0.4 | ------ |
| 38 | Puto sekong bilog | Toasted rice bread preparation | 388 | 4.8 | 6.0 | 1.8 | 0.4 | 87.0 | 1.8 | 15 | 56 | 2.2 | ------ | 0.06 | 0.02 | 0.5 | ------ |
| 39 | Puto sekong habang may niyog | Toasted rice bread preparation with coconut | 402 | 5.8 | 4.4 | 5.5 | 0.5 | 83.8 | 2.9 | 23 | 60 | 3.1 | ------ | 0.02 | 0.02 | 0.6 | ------ |
| 40 | Sapin-sapin | Glutinous rice preparation | 129 | 68.1 | 1.1 | 0.4 | 0.1 | 30.3 | ------ | 9 | 16 | 1.4 | ------ | 0.01 | 0.01 | 0.2 | ------ |
| 41 | Siopaw na baboy | Pork siopao | 295 | 40.2 | 9.0 | 12.3 | 1.5 | 37.0 | ------ | 40 | 97 | 2.7 | ------ | 0.17 | 0.13 | 2.1 | ------ |
| 42 | Siopaw na munggo | Mongo siopao | 279 | 33.6 | 6.7 | 2.9 | 0.4 | 56.4 | 2.9 | 28 | 68 | 3.4 | ------ | 0.14 | 0.11 | 1.6 | ------ |
| 43 | Suman sa ibos | Glutinous rice cake wrapped in blades nepa leaf | 171 | 57.5 | 3.1 | 0.7 | 0.7 | 38.0 | 0.4 | 15 | 26 | 1.2 | ------ | 0.01 | 0.01 | 0.3 | ------ |
| 44 | Suman sa lihiya | Glutinous rice preparation wrapped in banana leaf | 191 | 52.3 | 3.2 | 0.4 | 0.5 | 43.6 | 1.0 | 9 | 32 | 1.3 | ------ | traces | 0.02 | 0.5 | ------ |
| 45 | Sumang kameteng kahoy | Cassava cakes | 210 | 48.5 | 0.5 | 1.4 | 0.7 | 48.9 | 0.6 | 20 | 35 | 2.4 | ------ | 0.03 | 0.02 | 0.5 | ------ |
| 46 | Sumang matuwelkos | Glutinous rice product with grated coconut | 211 | 49.8 | 2.6 | 2.4 | 0.4 | 44.8 | 1.9 | 15 | 60 | 2.1 | ------ | 0.03 | 0.03 | 0.6 | ------ |

TABLE 1.—*Cereal and grain products*—Continued.

| Item | Local name | English name | Representative values for 100 gm edible portion | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Calories | Moisture | Protein | Fat | Ash | Carbohydrate | Crude fiber | Calcium | Phosphorus | Iron | Vitamin A | Thiamine | Riboflavin | Niacin | Ascorbic acid |
| | | | *gm* | *gm* | *gm* | *gm* | *gm* | *gm* | *gm* | *mg* | *mg* | *mg* | IU | *mg* | *mg* | *mg* | *mg* |
| 47 | Sotanghon | Rice noodles | 361 | 13.0 | 3.5 | 0.4 | 0.3 | 82.8 | ..... | 26 | 34 | 1.2 | ..... | 0.01 | 0.01 | 0.1 | ..... |
| 48 | Sotanghong luto | Cooked rice noodles | 83 | 80.1 | 0.1 | 0.3 | 0 | 19.5 | ..... | 20 | 3 | 1.3 | ..... | 0 | 0 | 0 | ..... |
| 49 | Tamalis | Rice flour preparation | 101 | 75.2 | 1.3 | 0.2 | 0.8 | 21.8 | 0.5 | 25 | 38 | 2.0 | 15 | 0.01 | 0.02 | 0.4 | 2 |
| 50 | Tikoy | Glutinous rice cake | 266 | 33.7 | 2.5 | 0.3 | 0.1 | 63.4 | 1.0 | 31 | 17 | 2.2 | ..... | 0.02 | 0.02 | 0.4 | ..... |
| 51 | Tikoy na may mani | Glutinous rice cake with peanut | 247 | 40.1 | 6.4 | 1.8 | 0.3 | 51.4 | 1.0 | 18 | 52 | 4.3 | ..... | 0.05 | 0.03 | 1.2 | ..... |
| | TINAPAY, KEYK AT IBA PA | | | | | | | | | | | | | | | | |
| 52 | Apa | Wafer | 388 | 3.3 | 5.4 | 0.5 | 0.4 | 90.4 | ..... | 33 | 52 | 2.0 | ..... | 0.11 | 0.09 | 0.9 | ..... |
| 53 | Bitso-bitso | Chinese bakery product | 372 | 22.6 | 7.4 | 13.6 | 1.4 | 55.0 | ..... | 39 | 79 | 3.7 | ..... | 0.10 | 0.10 | 0.9 | ..... |
| 54 | Biskotso | Toasted bread | 413 | 5.4 | 9.3 | 7.8 | 1.2 | 76.3 | ..... | 44 | 92 | 3.1 | ..... | 0.17 | 0.14 | 3.3 | ..... |
| 55 | Biskuwit na "Gem" | Gem biscuit | 423 | 5.3 | 11.0 | 9.8 | 1.1 | 72.8 | ..... | 61 | 109 | 3.6 | ..... | 0.10 | 0.31 | 2.4 | ..... |
| 56 | Biskuwit na Jacobina espesyal | "Jacobina especial" biscuit | 449 | 3.3 | 7.0 | 13.6 | 1.4 | 74.7 | ..... | 60 | 89 | 3.9 | ..... | 0.09 | 0.07 | 2.5 | ..... |
| 57 | Brohas | Lady fingers | 389 | 10.5 | 8.6 | 6.7 | 0.7 | 73.5 | ..... | 66 | 136 | 1.5 | ..... | 0.13 | 0.16 | 1.4 | ..... |
| 58 | Kamatsili (tinapay) | Bakery product | 435 | 3.8 | 7.8 | 10.9 | 1.1 | 76.4 | ..... | 40 | 81 | 3.9 | ..... | 0.14 | 0.12 | 2.2 | ..... |
| 59 | Keyk, prutas | Fruit cake | 365 | 26.0 | 5.0 | 14.6 | 1.0 | 53.4 | ..... | 59 | 123 | 3.6 | ..... | 0.14 | 0.06 | 1.0 | ..... |
| 60 | Keyk | Hot cake | 269 | 40.8 | 8.4 | 7.7 | 1.6 | 41.5 | ..... | 238 | 156 | 4.2 | ..... | 0.15 | 0.25 | 1.3 | ..... |
| 61 | Keyk | Sponge cake | 306 | 29.0 | 8.2 | 5.3 | 1.2 | 56.3 | ..... | 162 | 156 | 3.7 | ..... | 0.12 | 0.23 | 1.5 | ..... |
| 62 | Keyk, sikulate | Chocolate cake | 389 | 19.3 | 5.6 | 14.2 | 1.3 | 59.6 | ..... | 63 | 102 | 3.0 | ..... | 0.21 | 0.05 | 1.0 | ..... |
| 63 | Kukis | Cookies | 445 | 2.2 | 5.7 | 11.5 | 1.0 | 79.6 | ..... | 25 | 96 | 3.3 | ..... | 0.33 | 0.27 | 4.1 | ..... |
| 64 | Kukis araro | Arrow-root cookies | 416 | 5.8 | 1.1 | 8.4 | 0.7 | 83.0 | ..... | 27 | 33 | 3.5 | ..... | 0.02 | 0.03 | 0.3 | ..... |
| 65 | Kukis na may mantikilya | Butter cookies | 506 | 1.0 | 8.3 | 23.1 | 1.5 | 66.1 | ..... | 121 | 213 | 2.3 | ..... | 0.14 | 0.29 | 1.6 | ..... |
| 66 | Kukis na may pili | Mixed nut cookies | 532 | 1.5 | 6.6 | 26.3 | 1.0 | 62.6 | ..... | 133 | 111 | 2.4 | ..... | 0.16 | 0.27 | 0.6 | ..... |
| 67 | Krackers, biscuit | Crackers | 481 | 2.7 | 7.5 | 19.4 | 1.4 | 69.0 | ..... | 30 | 58 | 2.8 | ..... | 0.13 | 0.19 | 3.6 | ..... |
| 68 | Krackers na maalat | Salted cracker | 440 | 3.2 | 10.2 | 12.3 | 2.3 | 72.0 | ..... | 29 | 93 | 5.1 | ..... | 0.14 | 0.23 | 4.9 | ..... |
| 69 | Donat | Doughnut | 391 | 20.9 | 7.6 | 15.6 | 0.9 | 55.0 | ..... | 51 | 87 | 2.3 | ..... | 0.19 | 0.09 | 2.0 | ..... |
| 70 | Empanada | Meat pie | 400 | 19.6 | 9.2 | 28.7 | 1.1 | 41.1 | ..... | 36 | 92 | 3.1 | ..... | 0.30 | 0.15 | 3.1 | ..... |
| 71 | Ensaymada | Sweet roll | 335 | 21.9 | 8.4 | 4.9 | 0.5 | 64.3 | ..... | 24 | 63 | 3.1 | ..... | 0.16 | 0.11 | 2.6 | ..... |
| 72 | Galyetas de patatas | Bakery product | 423 | 3.4 | 15.0 | 8.0 | 0.8 | 72.8 | ..... | 55 | 139 | 4.3 | ..... | 0.16 | 0.15 | 2.4 | ..... |
| 73 | Gurgurya | Bakery product | 525 | 3.7 | 6.7 | 28.1 | 0.3 | 61.2 | ..... | 18 | 50 | 3.2 | ..... | 0.13 | 0.06 | 2.1 | ..... |
| 74 | Hopyang baboy | Stuffed bakery product | 414 | 12.5 | 5.0 | 13.1 | 0.3 | 69.1 | 3.4 | 32 | 54 | 2.4 | ..... | 0.11 | 0.04 | 2.0 | ..... |
| 75 | Hopyang munggo | Stuffed bakery product | 383 | 18.5 | 6.5 | 12.0 | 0.7 | 62.3 | 1.7 | 25 | 94 | 6.7 | ..... | 0.12 | 0.11 | 1.2 | ..... |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 76 | Mamon | Plain cake | 388 | 17.5 | 5.4 | 12.1 | 0.7 | 64.3 | ------ | 83 | 87 | 1.7 | ------ | 0.10 | 0.08 | 1.2 | ------ |
| 77 | Mamong tostado | Toasted cake | 411 | 3.9 | 10.4 | 6.7 | 0.9 | 78.1 | ------ | 49 | 189 | 3.4 | ------ | 0.15 | 0.29 | 1.3 | ------ |
| 78 | Masapudrida | Bakery product | 384 | 4.6 | 4.8 | 0.8 | 0.4 | 89.4 | ------ | 27 | 48 | 1.5 | ------ | 0.13 | 0.08 | 2.1 | ------ |
| 79 | Ogay-ogay | Bakery product | 442 | 3.8 | 8.3 | 12.4 | 1.2 | 74.3 | ------ | 33 | 129 | 2.3 | ------ | 0.20 | 0.10 | 3.1 | 0 |
| 80 | Pan amerikano | American loaf | 333 | 22.9 | 9.7 | 5.6 | 0.9 | 60.9 | ------ | 77 | 95 | 3.9 | ------ | 0.20 | 0.16 | 3.3 | ------ |
| 81 | Pan de bonete | Bread | 323 | 23.6 | 12.3 | 4.5 | 1.2 | 58.4 | ------ | 40 | 76 | 3.1 | ------ | 0.21 | 0.12 | 2.2 | ------ |
| 82 | Pan de coco | Bread | 350 | 20.3 | 9.2 | 6.7 | 0.7 | 63.1 | 0 | 30 | 76 | 2.0 | ------ | 0.21 | .07 | .33 | ------ |
| 83 | Pan de liaon | Bread | 321 | 21.0 | 10.6 | 4.0 | 0.8 | 60.6 | ------ | 25 | 84 | 3.6 | ------ | 0.18 | 0.09 | 3.1 | ------ |
| 84 | Pan de sal | Bread | 370 | 24.6 | 10.1 | 4.5 | 1.0 | 59.8 | ------ | 24 | 75 | 3.0 | ------ | 0.22 | 0.15 | 3.0 | ------ |
| 85 | Pansensya | Bakery product | 397 | 4.6 | 6.9 | 3.4 | 0.5 | 84.6 | ------ | 39 | 82 | 2.3 | ------ | 0.16 | 0.19 | 1.5 | ------ |
| 86 | Pilipit | Bakery product | 466 | 3.2 | 6.7 | 16.3 | 0.3 | 73.5 | ------ | 21 | 44 | 3.1 | ------ | 0.11 | 0.07 | 2.0 | ------ |
| 87 | Pitisu | Cream puff | 232 | 35.7 | 5.4 | 7.5 | 0.6 | 50.8 | ------ | 60 | 77 | 1.6 | ------ | 0.10 | 0.09 | 0.8 | ------ |
| 88 | Pivanono | Jelly rolls | 319 | 23.3 | 7.3 | 2.9 | 0.6 | 65.9 | ------ | 41 | 84 | 3.8 | ------ | 0.17 | 0.11 | 1.7 | ------ |
| 89 | Pulboron | Bakery product | 497 | 4.3 | 5.3 | 23.2 | 0.5 | 66.8 | ------ | 23 | 59 | 1.4 | ------ | 0.20 | 0.60 | 1.9 | ------ |
| 90 | Rolls | Rolls | 322 | 21.3 | 10.2 | 4.4 | 0.7 | 60.4 | ------ | 27 | 68 | 3.9 | ------ | 0.19 | 0.08 | 3.1 | ------ |
| 91 | Rolls, cinnamon | Cinnamon rolls | 419 | 16.3 | 9.1 | 17.7 | 1.0 | 55.9 | ------ | 55 | 89 | 2.6 | ------ | 0.18 | 0.13 | 1.9 | ------ |
| 92 | Rolls, cream filled | Cream-filled rolls | 366 | 27.9 | 9.2 | 16.3 | 1.0 | 45.6 | ------ | 63 | 163 | 2.7 | ------ | 0.06 | 0.25 | 0.7 | ------ |
| 93 | Rolls, marshmallow | Marshmallow roll | 339 | 20.9 | 6.5 | 4.9 | 0.6 | 67.1 | ------ | 46 | 124 | 2.3 | ------ | 0.11 | 0.21 | 0.7 | ------ |
| 94 | Roll na may pinya | Pineapple-filled rolls | 255 | 39.1 | 3.5 | 2.5 | 0.4 | 54.5 | 0.7 | 35 | 45 | 1.2 | ------ | 0.09 | 0.09 | 0.5 | 1 |
| 95 | Tinapay para sa diyabetiko | Diabetic loaf | 313 | 21.7 | 12.1 | 0.9 | 1.2 | 64.1 | ------ | 43 | 88 | 2.1 | ------ | 0.29 | 0.21 | 2.3 | ------ |
| 96 | Wafer, apa | Wafer | 505 | 2.5 | 4.6 | 23.2 | 0.4 | 69.4 | ------ | 36 | 55 | 1.9 | ------ | 0.02 | 0.10 | 1.7 | ------ |

TABLE 2.—*Fruit and vegetable products.*

| Item | Local name | English name | Representavie values for 100 gm edible portion | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Calories | Moisture | Protein | Fat | Ash | Carbohydrate | Crude fiber | Calcium | Phosphorus | Iron | Vitamin A | Thiamine | Riboflavin | Niacin | Ascorbic acid |
| | | | *gm* | *gm* | *gm* | *gm* | *gm* | *gm* | *gm* | *mg* | *mg* | *mg* | IU | *mg* | *mg* | *mg* | *mg* |
| 1 | Arina ng kamoteng kahoy | Cassava flour | 363 | 9.1 | 1.1 | 0.5 | 1.1 | 88.2 | 2.2 | 84 | 37 | 1.0 | ------ | 0.04 | 0.01 | 0.6 | ------ |
| 2 | Binusang kastanyas | Roasted cheatnut | 256 | 36.3 | 5.0 | 1.2 | 1.1 | 56.4 | 1.9 | 29 | 80 | 1.3 | ------ | 0.19 | 0.18 | 1.4 | ------ |
| 3 | Binusang kasuy | Roasted cashew | 603 | 6.2 | 19.1 | 47.4 | 2.3 | 25.0 | 0.7 | 37 | 441 | 3.3 | ------ | 0.48 | 0.23 | 1.5 | ------ |
| 4 | Binusang maning walang balat | Roasted peanut without skin | 564 | 6.3 | 30.6 | 49.4 | 2.7 | 11.0 | 1.9 | 68 | 400 | 2.3 | 0 | 0.20 | 0.12 | 15.0 | 6 |
| 5 | Binusang maning may balat | Roasted peanut with skin | 563 | 9.2 | 27.6 | 51.6 | 3.0 | 8.6 | 2.2 | 41 | 355 | 2.0 | 0 | 0.53 | 0.19 | 15.2 | 13 |
| 6 | Nilagang mani | Boiled peanut | 360 | 40.2 | 13.5 | 31.2 | 2.3 | 12.8 | 2.4 | 42 | 177 | 1.4 | 0 | 0.44 | 0.12 | 5.8 | 5 |
| 7 | Mansanitas | | 333 | 16.9 | 1.1 | 0.5 | 0.6 | 80.9 | 3.1 | 56 | 25 | 1.5 | ------ | 0.03 | 0.05 | 0.3 | 44 |
| 8 | Miso | Soybean paste | 144 | 66.2 | 13.0 | 3.5 | 2.2 | 15.1 | 4.9 | 107 | 112 | 2.3 | 12 | 0.09 | 0.06 | 0.4 | 1 |
| 9 | Pasas na walang buto | Seedless raisin | 340 | 14.6 | 3.5 | 1.1 | 1.9 | 78.9 | 1.7 | 76 | 125 | 3.8 | ------ | 0.14 | 0.14 | 0.4 | 8 |
| 10 | Pruns | Prunes | 278 | 29.0 | 2.5 | 0.7 | 2.3 | 65.5 | 1.8 | 67 | 89 | 5.3 | ------ | 0.04 | 0.09 | 1.4 | 8 |
| 11 | Soybean milk gata ng balatong | Soybean milk | 31 | 87.6 | 2.7 | 0.9 | 0.4 | 8.4 | ------ | 36 | 33 | 0.5 | 7 | 0.18 | 0.08 | 1.5 | ------ |
| 12 | Soybean milk na may tsokolate, gata ng balatong na may tsokolate | Soybean milk chocolate flavored | 37 | 81.0 | 2.2 | 0.3 | 0.4 | 16.1 | ------ | 44 | 44 | 0.4 | 5 | 0.13 | 0.10 | 1.5 | ------ |
| 13 | Tahong walang pulot | Geerling's cheese without syrup | 26 | 92.7 | 2.9 | 1.4 | 0.6 | 2.4 | ------ | 121 | 46 | 0.7 | ------ | 0.04 | 0.03 | 0.1 | ------ |
| 14 | Tahuri | Fermented soybean curd | 102 | 61.4 | 12.5 | 6.5 | 17.1 | 2.5 | ------ | 86 | 93 | 9.2 | ------ | 0.02 | 0.13 | 0.4 | ------ |
| 15 | Tausi | Fermented salted bean | 117 | 57.1 | 11.4 | 6.7 | 12.2 | 12.6 | 2.1 | 128 | 131 | 3.9 | 50 | 0.02 | 0.29 | 1.7 | 4 |
| 16 | Tokwa | Soybean cheese | 101 | 78.0 | 12.9 | 6.8 | 1.1 | 1.2 | ------ | 153 | 119 | 1.7 | ------ | 0.05 | 0.05 | 0.2 | ------ |
| 17 | Toyo | Soy sauce | 47 | 59.6 | 2.9 | 0.7 | 18.4 | 18.4 | ------ | 57 | 54 | 6.7 | ------ | ------ | 0.30 | 0.4 | ------ |

TABLE 3.—*Meat, fish and poultry products.*

| Item | Local name | Scientific name | English name | Representative values for 100 gm edible portion | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Calories | Moisture | Protein | Fat | Ash | Carbohydrate | Crude fiber | Calcium | Phosphorus | Iron | Vitamin A | Thiamine | Riboflavin | Niacin | Ascorbic acid |
| | | | | | *gm* | *gm* | *gm* | *gm* | *gm* | *gm* | *mg* | *mg* | *mg* | IU | *mg* | *mg* | *mg* | *mg* |
| 1 | Daing na alakaak | *Pseudoscaena aneа* | Dried plain croaker | 223 | 37.2 | 39.3 | 6.1 | 17.1 | ------ | ------ | 235 | 218 | 2.0 | ----- | 0.01 | 0.08 | 4.3 | ----- |
| 2 | Tuyong alamang | *Leander* sp. | Dried small shrimp | 299 | 21.6 | 59.4 | 3.6 | 12.2 | 3.2 | ------ | 2,306 | 625 | 21.4 | ----- | 0.06 | 0.19 | 5.5 | ----- |
| 3 | Daing na alumahan | *Rastrelliger chrysozonus* | Dried stripped mackerel | 230 | 39.5 | 42.9 | 5.2 | 14.2 | ------ | ------ | 183 | 351 | 2.9 | ----- | 0.01 | 0.07 | 17.9 | ----- |
| 4 | Tuyong ayungin | *Therapon plumbeus* | Dried silver perch | 355 | 17.4 | 54.6 | 12.5 | 19.5 | ------ | ------ | 5,317 | 1,356 | 20.2 | ----- | 0.07 | 0.39 | 4.2 | ----- |
| 5 | Daing na bakalaw | *Gadus* sp. | Dried cod | 260 | 27.8 | 51.8 | 1.2 | 12.4 | 6.8 | ------ | 371 | 339 | 3.0 | ----- | 0.05 | 0.16 | 4.1 | ----- |
| 6 | Daing na bakoko | *Sparus berda* | Dried pomasid | 206 | 42.3 | 34.3 | 6.2 | 15.7 | 1.0 | ------ | 187 | 280 | 1.9 | ----- | 0.01 | 0.03 | 9.4 | ----- |
| 7 | Bagoong na alamang | *Acetes indicus* | Salted and fermented small shrimp | 73 | 63.3 | 14.9 | 1.0 | 20.6 | 0.2 | ------ | 469 | 228 | 5.4 | ----- | 0.01 | 0.10 | 1.6 | ----- |
| 8 | Bagoong na alamang (bastos) | *Acetes indicus* | ---do--- | 60 | 64.1 | 12.0 | 0.8 | 22.7 | 0.4 | ------ | 689 | 397 | 8.9 | ----- | 0.01 | 0.14 | 1.6 | ----- |
| 9 | Bagoong na hipon | *Gobies* sp. (Gobiidae) | Salted and fermented goby fry | 83 | 66.4 | 12.5 | 1.9 | 16.1 | 3.1 | ------ | 403 | 341 | 1.4 | ----- | 0.03 | 0.18 | 1.5 | ----- |
| 10 | Bagoong na isda | *Stolephorus* spp. | Salted and fermented long-jawed anchovy | 70 | 64.3 | 14.3 | 1.0 | 20.6 | ------ | ------ | 535 | 313 | 10.9 | ----- | traces | 0.13 | 3.8 | ----- |
| 11 | Bagoong na padas | Teuthididae | Salted and fermented siganid fry | 81 | 60.0 | 10.6 | 1.7 | 22.8 | 4.9 | ------ | 504 | 435 | 16.6 | ----- | 0.01 | 0.21 | 3.7 | ----- |
| 12 | Bagoong na talaba | *Ostrea* sp. | Salted and fermented oyster | 43 | 85.2 | 3.3 | 2.5 | 7.6 | 1.4 | ------ | 139 | 23 | 4.2 | ----- | traces | 0.09 | 0.4 | ----- |
| 13 | Tinapang bangos | *Chanos chanos* | Smoked milkfish | 183 | 63.3 | 27.5 | 6.6 | 2.2 | 1.5 | ------ | 80 | 195 | 1.1 | ----- | 0.03 | 0.03 | 7.4 | ----- |
| 14 | Daing na bisugo | *Nemipterus taeniopterus* | Dried ribbon finned hemipterid | 187 | 40.6 | 34.6 | 2.9 | 18.7 | 3.2 | ------ | 245 | 254 | 0.7 | ----- | 0.02 | 0.01 | 6.5 | ----- |

TABLE 3.—*Meat, fish and poultry products*—Continued.

| Item | Local name | Scientific name | English name | Representative values for 100 gm edible portion | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Calories | Moisture | Protein | Fat | Ash | Carbohydrate | Crude fiber | Calcium | Phosphorus | Iron | Vitamin A | Thiamine | Riboflavin | Niacin | Ascorbic acid |
| | | | | | gm | gm | gm | gm | gm | gm | mg | gm | gm | IU | mg | mg | mg | mg |
| 15 | Daing na kabasi | *Anodontostomachacunda* | Dried and salted bastard shad bosling | | | | | | | | | | | | | | | |
| 16 | Tinapang kabasi | *Anodontostomachacunda* | Smoked bastard shad bosling | 161 | 48.3 | 23.7 | 5.5 | 19.3 | 2.2 | ..... | 492 | 483 | 2.8 | ..... | 0.01 | 0.14 | 3.8 | ..... |
| 17 | Daing na kanduli | *Arius manillensis* | Dried Manila sea catfish | 110 | 66.7 | 23.0 | 2.1 | 2.8 | 0.4 | ..... | 302 | 219 | 0.8 | ..... | 0.03 | 0.06 | 4.1 | ..... |
| 18 | Kek yam | ..... | ..... | 219 | 39.8 | 45.4 | 2.6 | 15.0 | ..... | ..... | 147 | 324 | 4.2 | ..... | 0.03 | 0.06 | 2.4 | ..... |
| 19 | Kropok | ..... | ..... | 129 | 63.3 | 4.2 | 2.1 | 2.0 | 33.4 | ..... | 60 | 31 | 1.4 | ..... | 0.03 | 0.03 | 0.3 | ..... |
| 20 | Daing na dalagang bukid | *Caesio chrysozonus* | Kropeck | 501 | 4.7 | 3.0 | 25.5 | 3.2 | 62.6 | ..... | 52 | 46 | 3.8 | ..... | 0.06 | 0.02 | 0.3 | ..... |
| 21 | Dilis na binilad (pinatuyo) | *Stolephorus commersoni* | Dried golden anchovy | 248 | 38.4 | 41.6 | 4.9 | 8.3 | 3.2 | ..... | 122 | 236 | 1.0 | ..... | 0.13 | 0.03 | 5.4 | ..... |
| 22 | Bola-bolang isda | ..... | Fish balls | 331 | 16.7 | 63.7 | 4.2 | 13.3 | ..... | ..... | 2,381 | 1,489 | 23.4 | ..... | 0.01 | 0.23 | 7.5 | ..... |
| 23 | Maliit na frankfurter | ..... | Small frankfurter | 121 | 68.4 | 8.6 | 0.5 | 1.9 | 20.6 | ..... | 47 | 81 | 0.9 | ..... | 0.02 | 0.02 | 0.8 | ..... |
| 24 | Daing na galunggong | *Decapterus macrosoma* | Dried scad | 243 | 59.5 | 17.0 | 18.5 | 3.0 | 2.0 | ..... | 83 | 131 | 2.8 | ..... | 0.07 | 0.20 | 2.6 | ..... |
| 25 | Cinamas | *Stolephorus* spp. | Salted and fermented fish | 221 | 37.6 | 43.3 | 3.9 | 14.3 | 0.4 | ..... | 629 | 534 | 3.6 | ..... | 0.02 | 0.09 | 12.3 | ..... |
| 26 | Hamon | *Sus scrofa* | Pork ham | 137 | 49.0 | 26.7 | 2.5 | 21.6 | ..... | ..... | 820 | 758 | 8.3 | ..... | 0 | 0.27 | 5.0 | ..... |
| 27 | Tinapang hasa-hasa | *Rastrelliger brachysomus* | Smoked short-bodied mackerel | 370 | 46.1 | 20.0 | 31.5 | 2.4 | ..... | ..... | 37 | 61 | 2.0 | ..... | 0.51 | 0.33 | 2.9 | ..... |
| 28 | Hibi | Palaemonidae | Salted dried shrimp | 146 | 61.9 | 30.0 | 1.7 | 5.8 | 0.6 | ..... | 52 | 239 | 1.2 | ..... | 0.02 | 0.09 | 9.8 | ..... |
| 29. | Hatdog | ..... | Hot dog | 254 | 29.6 | 52.9 | 1.8 | 12.9 | 2.8 | ..... | 1,048 | 512 | 5.5 | ..... | 0.02 | 0.05 | 3.3 | ..... |
| 30. | Longganisa | *Sus scrofa* Linn. var. | Sausage | 234 | 61.1 | 12.7 | 8.3 | 3.3 | 4.6 | ..... | 76 | 108 | 3.5 | ..... | 0.04 | 0.18 | 2.1 | ..... |
| 31. | Longganisang baboy at baka | *Sus scrofa* Linn. var. | Mixed sausage (pork and beef) | 590 | 24.9 | 8.3 | 60.0 | 3.3 | 3.5 | ..... | 25 | 61 | 1.2 | ..... | 0.33 | 0.14 | 2.2 | ..... |
| | | | | 452 | 37.6 | 14.5 | 42.3 | 3.3 | 2.3 | ..... | 23 | 61 | 1.1 | ..... | 0.10 | 0.21 | 1.1 | ..... |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32. | Longganisang makaw | *Sus scrofa* Linn. var. | Chinese sausage | 763 | 3.6 | 14.9 | 77.5 | 2.5 | 1.5 | ..... | 28 | 39 | 1.6 | ..... | 0.03 | 0.17 | 0.6 | ..... |
| 33. | Surisong bilbaw | *Sus scrofa* Linn. var. | Canned sausage | 831 | 3.6 | 3.7 | 90.0 | 1.7 | 0.9 | ..... | 27 | 14 | 0.9 | ..... | 0.05 | 0.05 | 0.4 | ..... |
| 34. | Daing na lapu-lapu | *Epinephelus coralicola* | Dried spotted grouper | 238 | 40.7 | 38.9 | 2.0 | 5.3 | 13.1 | ..... | 178 | 208 | 1.1 | ..... | 0.01 | 0.01 | 2.6 | ..... |
| 35. | Daing na matang-baka | *Caranx crumenophthalmus* | Dried big-eyed scad | 182 | 41.7 | 37.8 | 1.5 | 17.4 | 1.6 | ..... | 332 | 217 | 5.1 | ..... | 0.02 | 0.05 | 13.5 | ..... |
| 36. | Tinapang matang-baka | *Caranx crumenophthalmus* | Smoked big-eyed scad | 199 | 56.7 | 35.5 | 5.3 | 3.1 | ..... | ..... | 101 | 186 | 1.5 | ..... | 0.01 | 0.08 | 8.7 | ..... |
| 37. | Patis | ..... | Fish sauce | 59 | 63.6 | 9.5 | 0.1 | 22.6 | 3.8 | ..... | 37 | 36 | 2.8 | ..... | traces | 0.09 | 4.4 | ..... |
| 38. | Balut | *Anas domesticus* | Fertilized duck's egg | 181 | 72.3 | 12.6 | 13.9 | 1.1 | 0.1 | ..... | 116 | 175 | 1.6 | ..... | 0.11 | 0.27 | 0.9 | 3 |
| 39. | Century egg | *Anas domesticus* | Century egg | 219 | 59.0 | 13.6 | 12.4 | 2.0 | 13.0 | ..... | 5 | 135 | 6.3 | ..... | 0.05 | 0.22 | 0.1 | ..... |
| 40. | Itlog na maalat | *Anas domesticus* | Salted duck's egg | 195 | 66.5 | 13.6 | 13.3 | 2.2 | 4.4 | ..... | 120 | 157 | 1.8 | ..... | 0.28 | 0.47 | 0.1 | ..... |
| 41. | Penoy | *Anas domesticus* | Hard boiled infertile egg | 202 | 67.5 | 13.6 | 14.4 | 1.0 | 3.5 | ..... | 98 | 190 | 1.4 | ..... | 0.22 | 0.41 | 0.1 | ..... |
| 42. | Tuyong pusit | *Loligo pealii* | Dried squid | 286 | 30.6 | 57.4 | 4.5 | 5.5 | ..... | ..... | 49 | 600 | 3.2 | ..... | 0.02 | 0.07 | 9.0 | ..... |
| 43. | Daing na salay-salay | *Caranx diedaba* | Dried crevalle | 320 | 32.2 | 48.4 | 12.6 | 3.7 | ..... | ..... | 207 | 366 | 1.4 | ..... | 0.03 | 0.11 | 11.3 | ..... |
| 44. | Daing na samaral | *Teuthis javus* | Dried Javan siganid | 188 | 42.7 | 38.2 | 1.8 | 14.9 | 2.4 | ..... | 213 | 288 | 1.2 | ..... | 0.05 | 0.08 | 5.6 | ..... |
| 45. | Tuyong sapsap | *Leiognathus equulus* | Dried common ponyfish | 230 | 36.8 | 43.4 | 4.9 | 15.0 | ..... | ..... | 203 | 290 | 1.3 | ..... | 0.01 | 0.02 | 3.4 | ..... |
| 46. | Siksarong baboy | *Sus scrofa* Linn. var. | Pig's crackling | 603 | 1.5 | 54.5 | 42.1 | 0.42 | 1.5 | ..... | 42 | 52 | 2.8 | ..... | 0.03 | 0.04 | 1.1 | ..... |
| 47. | Tuyong talaba | *Ostrea* sp. | Dried oyster | 376 | 13.1 | 46.0 | 7.9 | 8.1 | 24.9 | ..... | 319 | 524 | 33.1 | ..... | 0.09 | 0.08 | 4.2 | ..... |
| 48. | Daing na talakitok | *Caranx sexfasciatus* | Dried banded caravalla | 254 | 34.5 | 50.4 | 4.2 | 10.9 | ..... | ..... | 134 | 277 | 1.0 | ..... | 0.11 | 0.02 | 6.8 | ..... |
| 49. | Daing na tallong | *Mugil melanopterus* | Dried black finned mullet | 184 | 43.5 | 32.0 | 5.3 | 16.0 | 3.2 | ..... | 313 | 195 | 2.5 | ..... | traces | 0.10 | 2.5 | ..... |
| 50. | Daing na tamban | *Sardinella longiceps* | Dried Indian sardine | 179 | 43.1 | 37.4 | 1.1 | 16.0 | 2.4 | ..... | 283 | 315 | 3.7 | ..... | 0.01 | 0.11 | 14.5 | ..... |
| 51. | Tinapang tamban | *Sardinella longiceps* | Smoked Indian sardine | 174 | 58.5 | 33.2 | 3.6 | 5.1 | ..... | ..... | 203 | 175 | 0.8 | ..... | 0.01 | 0.09 | 5.0 | ..... |
| 52. | Daing na tanggingi | *Cybium commersoni* | Dried Spanish mackerel | 205 | 40.4 | 43.1 | 2.3 | 14.4 | ..... | ..... | 86 | 329 | 1.5 | ..... | 0.02 | 0.02 | 12.0 | ..... |
| 53. | Tapa | *Sus scrofa* Linn. var. | Dried pork | 256 | 52.8 | 17.9 | 14.2 | 4.3 | 2.5 | ..... | 62 | 96 | 2.5 | ..... | 0.51 | 0.33 | 2.9 | ..... |
| 54. | Tuyong tunsoy | *Sardinella fimbriata* | Dried fimbriated herring | 197 | 42.7 | 38.0 | 2.4 | 13.8 | 3.1 | ..... | 200 | 366 | 2.6 | ..... | 0.01 | 0.25 | 7.1 | ..... |
| 55. | Tuyong turay | *Sardinella sirm* | Dried spotted sardine | 179 | 43.1 | 37.4 | 1.1 | 16.0 | 2.4 | ..... | 283 | 315 | 3.7 | ..... | 0.01 | 0.11 | 14.5 | ..... |

TABLE 4.—*Milk and milk products.*

| Item | Local name | English name | Representative values for 100 gm edible portion | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Calories | Moisture | Protein | Fat | Ash | Carbohydrate | Crude fiber | Calcium | Phosphorus | Iron | Vitamin A | Thiamine | Riboflavin | Niacin | Ascorbic acid |
| | | | *gm* | *gm* | *gm* | *gm* | *gm* | *gm* | *gm* | *mg* | *mg* | *mg* | IU | *mg* | *mg* | *mg* | *mg* |
| 1. | Chocolait | Chocolait | 66 | 83.0 | 2.9 | 0.2 | 0.6 | 13.3 | ------ | 134 | 76 | 0.4 | ------ | 0.02 | 0.06 | 0.1 | ------ |
| 2. | Choco-malt | Milk chocolate | 408 | 0.9 | 10.2 | 6.2 | 2.5 | 80.2 | ------ | 337 | 335 | 2.2 | ------ | 0.14 | 0.41 | 2.1 | ------ |
| 3. | Kesong gawa sa bahay | Cottage cheese | 92 | 77.0 | 15.4 | 0.9 | 1.9 | 4.9 | ------ | 89 | 142 | 1.6 | ------ | 0.07 | 0.81 | 0.7 | ------ |
| 4. | Kesong kraft | Kraft cheese | 326 | 38.5 | 22.8 | 20.3 | 5.3 | 13.1 | ------ | 777 | 338 | 1.5 | ------ | 0.01 | 0.26 | 0.1 | ------ |
| 5. | Kesong puti | Native cheese | 285 | 51.0 | 12.3 | 26.5 | 10.2 | ------ | ------ | 288 | 130 | 4.6 | ------ | 0.02 | 0.11 | 0.2 | ------ |
| 6. | Gatas ng baka | Cow's milk | 61 | 88.3 | 3.2 | 3.5 | 0.7 | 4.3 | ------ | 143 | 60 | 0.2 | ------ | 0.03 | 0.12 | 0.1 | ------ |
| 7. | Gatas na pulbos ng baka | Cow's milk powder | 486 | 5.5 | 26.0 | 26.7 | 5.6 | 36.2 | ------ | 727 | 480 | traces | (1,400) | 0.28 | 1.70 | 0.3 | ------ |
| 8. | Gatas ng kalabaw | Carabao's milk | 160 | 73.8 | 6.3 | 12.0 | 0.8 | 7.1 | ------ | 216 | 101 | 0.2 | ------ | 0.04 | 0.18 | 0.1 | ------ |
| 9. | Gatas ng kambing | Goat's milk | 64 | 85.9 | 4.3 | 2.3 | 0.9 | 6.6 | ------ | 98 | 78 | 2.7 | ------ | 0.06 | 0.29 | 0.1 | ------ |
| 10. | Pulberon | Pulvoron | 458 | 2.7 | 6.8 | 16.4 | 0.5 | 73.6 | 0.4 | 68 | 93 | 2.2 | ------ | 0.21 | 0.17 | 2.0 | ------ |

TABLE 5.—*Sugar products.*

| Item | Local name | English name | Representative values for 100 gm edible portion | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Calories | Moisture | Protein | Fat | Ash | Carbohydrate | Crude fiber | Calcium | Phosphorus | Iron | Vitamin A | Thiamine | Riboflavin | Niacin | Ascorbic acid |
| | | | | *gm* | *gm* | *gm* | *gm* | *gm* | *gm* | *mg* | *mg* | A | IU | *mg* | *mg* | *mg* | *mg* |
| 1 | Manipis na piraso ng matamis na saging | Banana chips | 503 | 3.6 | 2.9 | 24.9 | 1.8 | 66.8 | 0.9 | 53 | 69 | 1.4 | 514 | 0.05 | 0.06 | 0.7 | ------ |
| 2 | Banana crackers | Banana crackers | 518 | 4.2 | 2.1 | 27.7 | 1.0 | 65.0 | 0.7 | 38 | 55 | 2.5 | 190 | 0.05 | 0.07 | 0.6 | ------ |
| 3 | Peanut crackers | Peanut crackers | 541 | 1.6 | 23.0 | 31.2 | 2.1 | 42.1 | 9.8 | 58 | 243 | 3.7 | ------ | 0.19 | 0.10 | 8.6 | ------ |
| 4 | Bibingkang gabi | Taro cake | 184 | 53.0 | 1.0 | 0.2 | 1.3 | 44.5 | 1.1 | 52 | 50 | 2.2 | ------ | 0.04 | 0.02 | 0.6 | ------ |
| 5 | Halayang bayabas | Canned guava jelly | 346 | 14.2 | 0 | 0.6 | 0.04 | 85.2 | ------ | 4 | 4 | 0.9 | ------ | traces | 0.01 | 0.2 | 2 |
| 6 | Karameto | Carameto | 400 | 0.4 | 0 | 0.3 | 0.1 | 99.2 | ------ | 3 | 2 | 0.3 | ------ | traces | 0.01 | 0.1 | ------ |
| 7 | Kending kundol | Wax gourd candy | 327 | 18.3 | 0.2 | 0.1 | 0.2 | 81.2 | 1.1 | 50 | 7 | 1.2 | ------ | traces | 0.01 | 0.1 | ------ |
| 8 | Lohuwa sa bigas | Puffed rice | 415 | 6.6 | 3.4 | 8.4 | 0.2 | 81.4 | ------ | 10 | 28 | 3.0 | ------ | 0.02 | 0.02 | 0.4 | ------ |
| 9 | Lohuwa sa linga | Puffed rice with sesame | 503 | 4.3 | 10.7 | 25.2 | 1.4 | 58.4 | ------ | 84 | 330 | 2.0 | ------ | 0.27 | 0.04 | 2.3 | ------ |
| 10 | Lohuwa sa mani | Puffed rice with peanuts | 500 | 5.7 | 16.9 | 25.6 | 1.2 | 50.6 | ------ | 48 | 211 | 4.4 | ------ | 0.12 | 0.06 | 5.2 | ------ |
| 11 | Matamis na linga | Sweet sesame | 496 | 2.4 | 19.1 | 26.7 | 1.1 | 50.7 | 1.1 | 47 | 161 | 1.6 | ------ | 0.12 | 0.03 | 4.5 | ------ |
| 12 | Matamis na maning buo | Whole peanut brittle | 597 | 2.2 | 15.4 | 39.0 | 2.0 | 49.5 | 3.0 | 65 | 180 | 1.8 | ------ | 0.29 | 0.07 | 8.5 | ------ |
| 13 | Matamis na maning durog | Ground peanut brittle | 512 | 2.3 | 18.5 | 28.5 | 1.3 | 49.4 | 1.7 | 48 | 197 | 1.9 | ------ | 0.14 | 0.06 | 6.2 | ------ |
| 14 | Matamis na maning may linga | Peanut brittle with sesame | 523 | 2.7 | 12.2 | 27.9 | 1.4 | 55.8 | 1.5 | 54 | 178 | 1.3 | ------ | 0.20 | 0.05 | 5.0 | ------ |
| 15 | Matamis na maning may panutsa | Peanut candy | 433 | 8.4 | 10.6 | 14.6 | 1.6 | 64.8 | 1.3 | 32 | 157 | 2.3 | ------ | 0.12 | 0.10 | 4.5 | ------ |
| 16 | Turong matamis na mani | Peanut candy | 535 | 2.3 | 20.3 | 29.9 | 1.4 | 46.1 | 6.4 | 43 | 234 | 2.7 | ------ | 0.11 | 0.09 | 6.7 | ------ |
| 17 | Matamis na bao | Coco honey | 380 | 6.9 | 0.9 | 1.8 | 0.4 | 90.0 | ------ | 7 | 27 | 0.6 | ------ | 0.01 | 0.03 | 0.1 | ------ |
| 18 | Nata de coco | Nata de coco | 142 | 64.7 | 0 | 0.2 | traces | 35.1 | ------ | 12 | 1 | 0.5 | ------ | traces | 0.01 | traces | ------ |
| 19 | Nata de pinya | Nata de piña | 181 | 55.1 | 0 | 0.2 | traces | 44.7 | ------ | 10 | 4 | 0.7 | ------ | traces | 0.01 | traces | 2 |
| 20 | Pastillyas na gatas | Milk fudge | 370 | 7.4 | 9.9 | 1.4 | 1.8 | 79.5 | ------ | 370 | 224 | 0.6 | ------ | 0.08 | 0.38 | 0.3 | ------ |
| 21 | Pastillyas na ubi | Yam fudge | 344 | 13.8 | 10.2 | 1.8 | 2.4 | 71.8 | ------ | 140 | 174 | 3.0 | ------ | 0.07 | 0.11 | 0.3 | ------ |
| 22 | Pastillyas na langka | Jackfruit fudge | 358 | 8.9 | 8.9 | 0.3 | 2.0 | 79.9 | 0.2 | 350 | 250 | 1.8 | 14 | 0.07 | 0.35 | 0.2 | 4 |
| 23 | Matamis na pili | Candied pilinut | 595 | 1.0 | 7.5 | 41.2 | 1.3 | 48.6 | 4.9 | 91 | 321 | 3.7 | ------ | 0.19 | 0.04 | 0.1 | 5 |
| 24 | Turong pili | Candied pilinut | 539 | 1.7 | 5.7 | 30.1 | 1.7 | 61.2 | 23.2 | 58 | 277 | 5.7 | ------ | 0.15 | 0.06 | 0.2 | 7 |
| 25 | Matamis na rimas | Breadfruit candy | 341 | 15.1 | 0.6 | 0.5 | 0.4 | 83.4 | 1.3 | 90 | 10 | 1.0 | ------ | traces | 0.02 | 0.3 | ------ |
| 26 | Tsampoy na sampalok | Candied tamarind | 386 | 2.5 | 0.2 | 0.5 | 1.6 | 95.2 | 0.5 | 36 | 11 | 2.4 | ------ | 0.05 | 0.02 | 0.2 | 2 |
| 27 | Ubido (ubidolse) | Yam fudge | 346 | 8.7 | 6.7 | 1.6 | 1.8 | 81.2 | ------ | 78 | 65 | 2.6 | ------ | 0.07 | 0.15 | 0.3 | ------ |

TABLE 6.—*Miscellaneous products.*

| Item | Local name | English name | Representative values for 100 gm edible portion | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Calories | Moisture | Protein | Fat | Ash | Carbohydrate | Crude fiber | Calcium | Phosphorus | Iron | Vitamin A | Thiamine | Riboflavin | Niacin | Ascorbic acid |
| | | | | *gm* | *gm* | *gm* | *gm* | *gm* | *gm* | *mg* | *mg* | *mg* | IU | *mg* | *mg* | *mg* | *mg* |
| 1 | Sarsang saging | Banana sauce | 221 | 42.1 | 0.7 | 0.2 | 3.0 | 54.0 | 0.5 | 33 | 11 | 1.6 | 20 | 0.02 | 0.02 | 0.3 | 2 |
| 2 | Binusang kakaw | Roasted cocoa beans | 374 | 0.5 | 11.6 | 34.1 | 3.4 | 50.4 | 27.8 | 255 | 446 | 2.9 | ------ | 0.03 | 0.13 | 1.3 | ------ |
| 3 | Kapeng pulbos | Soluble coffee | 356 | 2.7 | 17.8 | 1.3 | 9.9 | 68.3 | ------ | 296 | 368 | 5.9 | ------ | traces | 0.22 | 41.6 | ------ |
| 4 | Sarsang kamatis | Tomato sauce | 44 | 87.2 | 1.2 | 0.3 | 2.2 | 9.1 | 1.5 | 26 | 31 | 1.3 | 874 | 0.07 | 0.03 | 1.3 | 8 |
| 5 | Katsup na kamatis | Tomato catsup | 134 | 68.6 | 1.9 | 0.2 | 3.1 | 31.2 | 0.3 | 30 | 29 | 1.2 | 758 | 0.08 | 0.04 | 1.7 | 11 |
| 6 | Gulamang pula | Red Ceylon moss | 311 | 17.9 | 2.6 | 0.4 | 4.7 | 74.4 | ------ | 488 | 28 | 27.0 | ------ | 0.02 | 0.02 | 0.1 | ------ |
| 7 | Likyam | Likiam | 246 | 32.2 | 1.9 | 1.6 | 8.2 | 56.1 | 1.6 | 90 | 66 | 2.2 | 180 | 0.03 | 0.05 | 0.6 | 0 |
| 8 | Nido | Bird's nest | 281 | 24.8 | 37.5 | 0.3 | 5.3 | 32.1 | ------ | 485 | 18 | 3.3 | ------ | traces | 0.02 | 0.2 | ------ |
| 9 | Inangkat na pulbos ng kakaw | Imported powdered cocoa | 281 | 3.1 | 20.0 | 21.1 | 4.8 | 50.9 | ------ | 112 | 592 | 6.6 | ------ | 0.02 | 0.02 | 2.2 | ------ |
| 10 | Katutubong pulbos ng kakaw | Local cocoa | 272 | 2.7 | 21.7 | 19.8 | 5.9 | 49.9 | ------ | 183 | 647 | 16.7 | ------ | 0.07 | 0.20 | 2.1 | ------ |
| 11 | Sopas na manok | Cooked chicken noodle soup | 25 | 93.3 | 1.6 | 0.4 | 1.0 | 3.7 | ------ | 36 | 5 | 0.6 | ------ | 0.14 | 0.30 | 0.2 | traces |
| 12 | Tea | Tea | 357 | 7.4 | 21.7 | 1.0 | 4.6 | 65.3 | 11.2 | 656 | 253 | 18.4 | 2097 | 0.01 | 0.70 | 6.8 | ------ |
| 13 | Tuba | Fermented palm sap | 47 | 88.1 | 0.2 | 0.2 | 0.3 | 11.2 | ------ | 32 | 13 | 0.5 | ------ | 0.01 | 0.03 | 0.5 | 6 |

# RELATIVE STABILITIES OF SOME ALLYLIC CYCLIC ISOMERS *

By O. S. PASCUAL

*Philippine Atomic Research Center, Diliman, Quezon City*

and

ZENAIDA S. GARCIA

(Received for publication, April 6, 1963.)

The allylic pair 2-methylenecyclohexanol (I) and 1-cyclohexenemethanol (II) and their 5-ring homologs, 2-methylenecylopentanol (III) and 1-cyclopentenemethanol (IV), were found to rearrange to their isomeric 2-methylcyloalkanones in the presence of sulfuric acid.[1] Their availability to us in connection with other studies gave us the opportunity to compare their relative thermochemical stabilities through their heats of combustion and thereby provide some clues to the perplexing problem of relative isomer stabilities in allylic cyclic systems. The combustion results are summarized in Table 1 and the details in Table 2.

TABLE 1.—*Heats of combustion of some cyclic compounds.*

| Compound | $-\Delta H_c$ (kcal.mole$^{-1}$) |
|---|---|
| 1-Cyclopentenemethanol | 914.1 ± 0.8 |
| 2-Methylenecyclopentanol | 917.1 ± 0.9 |
| 2-Methylcyclopentanone | 842.5 ± 1.3 |
| 1-Cyclohexenemethanol | 976.8 ± 0.5 |
| 2-Methylenecyclohexanol | 1001.9 ± 0.8 |
| 2-Methylcyclohexanone | 999.4 ± 0.8 |

From the data in Table 1, the *endo*-isomer (cycloalkenemethanol) is more stable (thermochemically) than the *exo*-isomer (2-methylenecycloalkanol) in both 5- and 6-ring systems although the magnitude of the differences in stability depends on ring size (25.1 kcal.mole$^{-1}$ for the 6-ring isomers and 3.0 kcal.mole$^{-1}$ for the 5-ring analogs). Studies on the heats of hydrogenation of the 5- and 6-ring allylic olefin pair, methylenecycloalkane and 1-methylcycloalkene, also show the greater stability of the

* Work done at the Department of Chemistry, University of the Philippines.

[1] Dreiding, A. S., and J. S. Hartman [Jour. Am. Chem. Soc. 78 (1956) 1216] undertook the rearrangement to verify the prediction of O. H. Wheeler [Chem. Ind. (1954) 900] that the *endo*-isoner would be preferred over the *exo*-isomer in the 6-ring system and conversely for the 5-ring system. The prediction is erroneous since the transformations are outside the scope of the I-strain theory.

TABLE 2.—*Data on heats of combustion.*

| Compound | Mass | Temperature rise, °F | −q (benzoic acid) | Corrections, BTU | | | $-\Delta E_c$ Kcal.mole$^{-1}$ | $-\Delta H_c$ Kcal.mole$^{-1}$ |
|---|---|---|---|---|---|---|---|---|
| | | | | −q (gelatin) | −q (acid) | −q (fuse wire) | | |
| | *gm* | | | | | | | |
| 1-Cyclopentenemethanol | 0.9791 | 6.697 | ---------- | ---------- | 27.00 | 24.00 | 914.11 | 915.63 |
| | 0.8856 | 6.051 | ---------- | ---------- | 25.80 | 28.50 | 912.64 | 914.15 |
| | 0.8889 | 6.074 | ---------- | ---------- | 25.90 | 34.00 | 912.46 | 913.9 |
| | 0.9001 | 6.132 | ---------- | ---------- | 22.00 | 26.50 | 910.96 | 912.48 |
| | | | | | | | Average = 914.06 ± 0.80 | |
| 1-Cyclohexenemethanol | 0.4747 | 5.112 | 4081.19 | 966.36 | 24.50 | 32.50 | 974.58 | 976.10 |
| | 0.4689 | 5.064 | 3980.05 | 1038.28 | 25.40 | 27.50 | 975.42 | 976.94 |
| | 0.5011 | 5.316 | 4088.02 | 1040.70 | 26.30 | 27.00 | 975.88 | 977.40 |
| | | | | | | | Average = 976.81 ± 0.48 | |
| 2-Methylenecyclopentanol | 0.8080 | 5.543 | ---------- | ---------- | 23.90 | 27.00 | 916.22 | 917.74 |
| | 0.7627 | 5.238 | ---------- | ---------- | 21.80 | 40.00 | 916.24 | 917.75 |
| | 0.9276 | 6.350 | ---------- | ---------- | 28.70 | 31.00 | 914.20 | 915.71 |
| | | | | | | | Average = 917.07 ± 0.90 | |
| 2-Methylenecyclohexanol | 0.4932 | 5.381 | 4224.40 | 1010.81 | 20.30 | 23.50 | 999.36 | 1000.83 |
| | 0.4718 | 5.151 | 3963.00 | 1039.89 | 24.50 | 11.00 | 1002.02 | 1003.53 |
| | 0.4693 | 5.708 | 5364.31 | 1031.82 | 28.30 | 26.00 | 1000.43 | 1001.93 |
| | 0.4517 | 5.077 | 4118.70 | 1033.43 | 24.50 | 20.00 | 999.56 | 1001.08 |
| | | | | | | | Average = 1001.86 ± 0.78 | |
| 2-Methylcyclopentanone | 0.4441 | 5.402 | 5215.43 | 1053.63 | 29.75 | 27.00 | 842.87 | 844.08 |
| | 0.4904 | 6.163 | 6338.30 | 1094.84 | 32.60 | 33.50 | 839.44 | 840.66 |
| | 0.4822 | 5.488 | 4822.20 | 1060.90 | 31.70 | 36.00 | 842.44 | 843.64 |
| | 0.1191 | 5.277 | 9863.74 | 1132.01 | 25.55 | 28.50 | 840.59 | 841.80 |
| | | | | | | | Average = 842.54 ± 1.31 | |
| 2-Methylcyclohexanone | 0.4461 | 5.102 | 4286.90 | 1023.74 | 25.60 | 21.00 | 998.12 | 999.65 |
| | 0.4718 | 5.121 | 3864.12 | 1071.41 | 26.30 | 24.00 | 999.27 | 1000.73 |
| | 0.4549 | 5.203 | 4332.36 | 1077.06 | 27.70 | 35.00 | 996.97 | 998.47 |
| | 0.4857 | 5.302 | 4148.25 | 1022.93 | 26.90 | 23.00 | 997.36 | 998.88 |
| | | | | | | | Average = 999.44 ± 0.76 | |

*endo*-isomer for both the 5- (3.81 kal.mole$^{-1}$) and the 6-ring (2.12 kcal.mole$^{-1}$) systems.[2] The almost constant difference in thermochemical stability between the 5-ring *exo-endo*-isomer pair as we go from the olefin (3.8 kcal.mole$^{-1}$) to the olefin alcohol (3.0 kcal.mole$^{-1}$) may be due to a similar increase in strain in both allylic alcohol isomers (relative to the olefins).

When the 6-ring olefin alcohols are corrected to 5-ring systems by subtracting 157.2 kcal.mole$^{-1}$, the heat of combustion per $CH_2$-group in a 6-ring,[3] the difference in stability between the *exo* homologs (now isomers) and that between the *endo* homologs (now isomers also) may be calculated.[4] The difference in stability between the *endo* analogs (94.5 kcal.mole$^{-1}$) is larger than that between the *exo* analogs (72.4 kcal.mole$^{-1}$). This agrees with the hydrogenation studies of Garner and Turner[2] but not with the second assumption of Brown, at al.[5] which requires that "the difference in stability between double bonds *exo* to 5- and 6-membered rings is larger than the difference in stability between *endo*-double bonds in these ring systems."

Thermochemically, 2-methylcyclopentanone is more stable compared to its *exo*-isomer, 2-methylenecyclopentanol (77.0 kcal.mole$^{-1}$) as well as to its *endo*-isomeric alcohol (1-cyclopentenemethanol; 74.0 kcal.mole$^{-1}$). On the other hand, 2-methylcyclohexanone is stable relative to its *exo*-isomeric alcohol[6] (2-methylenecyclohexanol; 2.5 kcal.mole$^{-1}$) but unstable with respect to the *endo* alcohol (1-cyclohexenemethanol; 22.6 kcal. mole$^{-1}$). Therefore, the rearrangements of 1-cyclopentenemethanol, 2-methylenecyclopentanol and 2-methylenecyclohexanol to their corresponding ketones may be attributed to favorable energy ($\Delta H$) differences. However, the rearrangement of 1-cyclohexenemethanol cannot be accounted for on the same basis. The latter transformation may be due to a large entropy of isomerization. A large entropy of isomerization has been observed in the conversion of methylenecyclohexane to 1-methyl-

[2] Garner, R. H., and R. B. Turner, Jour. Am. Chem. Soc. 79 (1957) 253; ibid. 80 (1958) 1424.

[3] Spitzer, R., and H. Huffman, Jour. Am. Chem. Soc. 69 (1947) 211.

[4] Strictly, one may speak only of the relative stability of isomeric compounds since it is only in these cases that the energies of the products of combustion are identical.

[5] Brown, H. C., J. H. Brewster, and H. Shechter, Jour. Am. Chem. Soc. 76 (1954) 467.

[6] Probably due to the greater interaction between the *exo* methylene group and the alpha-hydroxy group compared to that between the keto group and the alpha-methyl group in the ketone.

clohexene[7, 8] but not in the 5-ring homolog.[9] This suggests that in transformations involving the 6-ring system, favorable energy ($\Delta H$) differences may not be required for product control.

## EXPERIMENTAL

### PREPARATION OF THE CYCLIC COMPOUNDS

*2-Methylenecyclohexanol and 1-cyclohexenemethanol.*—150ml of anhydrous methanol was added slowly to 23 gms (2.1 gm atoms) of newly cut sodium. After all the methanol was added, the mixture was refluxed until all the sodium had reacted. The excess methanol was removed at reduced pressure and water bath temperature. The sodium methoxide cake was broken up and placed in a 2-liter 2-neck flask equipped with a stirrer, a condenser and a dropping funnel. 200 ml of anhydrous ether was added to form a suspension. 200 gms (2.0 moles) of cyclohexanone was added to the suspension of the sodium methoxide prepared above. 152 gm (2.0 moles) of ethyl formate[10] was added slowly from the dropping funnel.[11] A yellow precipitate was formed. After the addition of the ethyl formate, the mixture was refluxed for 2 hours. The addition product was decomposed with ice. The ether layer was extracted with small portions of cold 5 per cent NaOH solution. The combined extract and aqueous layer was acidified with cold 10 per cent HCl to pH 5. The 2-hydroxymethylenecyclohexanone[12] was extracted with ether, treated with solid ammonium carbonate, dried with anhydrous sodium sulfate and distilled. 80 gm (31 per cent) of the hydrindone was collected, b.p. 85° (12 mm); reported[11]: b.p. 80° (12 mm), $n_D^{20}$ 1.5130.

[7] Cope, A. C., A. Ambro, E. Ceganek, C. Howell, and Z. Jacura. Jour. Am. Chem. Soc. **81** (1959) 3153.

[8] It may be noted that in the case of 1-cyclohexenemethanol the isomerization is *endo* to *exo* rather than *exo* to *endo*.

[9] The small entropy of isomerization observed in the 5-ring homolog may be due to the easy convertibility between the two equilibrium conformations of the cyclopentane ring.

[10] Prepared by refluxing EtOH with $HCO_2H$ and $H_2SO_4$ in a flask equipped with a column provided with a take-off head. The distillate was dried with anhydrous $Na_2CO_3$ and redistilled, b. p. 53 to 54°.

[11] Modified from Plattner, P., P. Treadwell, and Co. Scholz, Helv. Chim. Acta. **28** (1945) 771.

[12] The hydrindone, especially of the 6-ring system, must be reacted immediately to minimize decomposition.

To a slurry consisting of 210 gm (0.55 mole) of lithium aluminum hydride and 310-ml anhydrous ether was added, dropwise, a solution of 69.30 gm (0.55 mole) of the hydrindone, 2-hydroxymethylenecyclohexanone, in 60 ml of anhydrous ether.[13] After refluxing for an hour, the solution was cooled and decomposed by carefully adding water to it. 240 ml of a 20-per cent aqueous solution of Rochelle salt was added to complex the lithium and aluminum salts. The ether layer was separated and the aqueous layer was extracted with ether. The combined ether extracts were washed with a salted solution of NaCl, dried with anhyd. $MgSO_4$ and distilled through a 12-inch helix-packed column. Collected were 40 gm (64 per cent yield) of 2-methylenecyclohexanol, b.p. 80° (27 mm), $d_4^{20}$ 0.8155, $n_D^{20}$ 1.4868 (reported[13]: b.p. 81 to 85° (27 mm); $n_D^{20}$ 1.4843); 15 gm (24 per cent yield) of 1-cyclohexenemethanol, b.p. 93 to 94° (27 mm) $d_4^{20}$ 0.8134 $n_D^{20}$ 1.4868 (reported[13]: b.p. 98 to 99° (27 mm); $n_D^{25}$ 1.4905) and 8.8 gm (11 per cent yield) of 2-hydroxymethylcyclohexanol, b.p. 87 to 90° (1 mm), $n_D^{25}$ 1.4920 (reported[14]; b.p. 114 to 15° (14 mm), $n_D^{20}$ 1.4923).

*2-Methylenecyclopentanol and 1-cyclopentenemethanol.*—The procedure for the 6-ring homolog was followed. 172 gm (2.0 moles) of freshly distilled cyclopentanone, 152 gm (2.0 moles) of ethyl formate and 23 gm (2.1 gm atoms) of sodium gave 90 gm (44 per cent yield) of 2-hydroxymethylenecyclopentanone, b.p. 115° (13 mm).

The reduction of 90 gm (0.9 mole) of the hydrindone with 34 gm (0.9 mole) of lithium aluminum hydride gave 27 gm (31 per cent yield) of 2-methylenecyclopentanol, b.p. 95 to 96° (5 mm), m.p. 59°, and 35 gm (39 per cent yield) of 1-cyclopentenemethanol, b.p. 102° (5 mm), m.p. 60°.

*2-Methylcyclohexanone.*—To a 2-liter 3-neck flask were placed 220 gm (0.9 mole) of potassium dichromate and 1 liter of water. 172 gm (1.8 moles) of $H_2SO_4$ was added slowly with stirring. The solution was cooled to 30° and 114° gm (1 mole) of 2-methylcyclohexanol[14] was added all at once. The temperature was maintained at 60° ± 3° with an ice-bath. When the reaction began to subside, the ice-bath was removed and the mixture was allowed to reach room temperature. The mixture

[13] Modified from Dreiding, A. S., and J. S. Hartman, Jour. Am. Chem. Soc. 75 (1953) 939.

[14] Obtained from Distillation Products Industries, Eastman Kodak Co.

was extracted with three 100-ml portions of benzene and dried with anhyd. $Na_2SO_4$. Distillation gave 76.5 gm (68 per cent yield) of 2-methylcyclohexanone, b.p. 68° (28 mm), $d_4^{20}$ 0.7850, $n_D^{20}$ 1.4492 (reported[15]: b.p. 165°, $n_D^{20}$ 1.4487).

*2-Methylcyclopentanone.*—175 gm (1.2 moles) of adipic acid was esterified[15] and the resulting ethyl adipate (156 gm, 0.78 mole, 65 per cent yield, b.p. 120 to 123° (11 mm) was cyclized[16] giving 93.5 gm (0.60 mole, 77 per cent yield) of 2-carbethoxycyclopentanone, b.p. 103 to 104° (13 mm); reported[17]: 108 to 111° (15 mm). The ketoester was methylated giving 2-carbethoxy-2-methylcyclopentanone[17] (41 gm, 0.24 mole, 40 per cent yield), b.p. 123 to 126° (11 mm): reported[17]: b.p. 106 to 107° (17 mm). Upon decarboxylation of the methyl ketoester, 5 gm (20 per cent yield) of 2-methylcyclopentanone was obtained, b.p. 140°, $n_D^{25}$ 1.4338, $n_D^{20}$ 1.4357 (reported[18]: b.p. 139.5°, $n_D^{25}$ 1.4341).

## DETERMINATION OF THE HEATS OF COMBUSTION

The compounds were burnt in a twin-valve Parr adiabatic oxygen bomb calorimeter.[19] The samples were placed in gelatin capsules and in cases where a catalyst was necessary, Baker primary standard reagent grade benzoic acid was used.

The water equivalent of the calorimeter was checked with standard benzoic acid. An average value of 2441.91 ± 0.55 BTU $deg^{-1}$ was obtained.

The $\Delta E_c$ values were converted into $\Delta H_c$, the standard heat of combustion, with the help of the equation:

$$\Delta H = \Delta E + (\Delta n)\ RT$$

The combustion data are collected in Table 2.

## ACKNOWLEDGMENT

The authors wish to express their appreciation to the Research Corporation (a Foundation) of New York City and to the University of the Philippines Natural Science Research Center for their generous financial support.

[15] Pinkney, P.S., Organic Syntheses. Coll. 2 (1943) 265.

[16] Linstead, R. P., and E. M. Meade, ibid. 2 (1943) 119.

[17] Adapted from Case, F. H., and E. E. Reid, Jour. Chem. Soc. 50 (1928) 3062–3065.

[18] Umland, J. B., and M. I. Jefraim, ibid. 78 (1956) 2788.

[19] Thanks are due to the Department of Chemical Engineering of the University of the Philippines, for giving the authors the opportunity of using their bomb calorimeter.

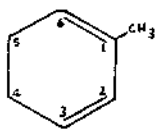
# RELATIVE STABILITIES OF SOME CONJUGATED OLEFINS*

By O. S. PASCUAL
*Philippine Atomic Research Center, Diliman, Quezon City*
and
E. ALMEDA

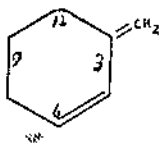
(Received for publication, April 6, 1963.)

THREE TEXT FIGURES

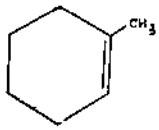
In this paper, a part of a study of the relative stabilities of cyclic olefins,[1] attention is focused on the isomer pairs: 1-methyl 2,6-cyclohexadiene (I) and 1-methylene 2-cyclohexene (II); 1-methylcyclohexene (III) and methylenecyclohexane (IV).



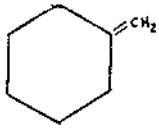

(I)




(II)




(III)




(IV)

The authors' interest on these olefins was due mainly to their curiosity as to the cause for the large difference in stability between conjugated chain compounds and their corresponding ring analogs,[2] e.g., hexatriene and benzene. Although the molecular orbital theory recognizes the existence of fundamental differences between ring and chain compounds due to the presence of high-energy bonding molecular orbitals[3] in the latter, the reason for this behavior still remains unknown.

* Work done at the Department of Chemistry of the University of the Philippines.

[1] Pascual O. S., and Z. S. Garcia, Philip. Jour. Sci. 93 (1964) 385–390.

[2] The very small conjugation in chain compounds are shown by the following: (*a*) The small shortening in the central carbon-carbon single bond in butadiene, about 0.02A after correcting for sigma-bond compression due to the change in hybridization of the carbon atom from tetrahedral to trigonal; (*b*) The much lower resonance energy of butadiene and other chain compounds (about 5 kcal.mol$^{-1}$) compared to ring compounds (about 30 to 40 kcal-mole$^{-1}$ per ring); (*c*) The similarity in the ionization potential of butadiene (9.07 ev) and propylene (9.6 ev) suggesting that the magnitude of the conjugation of the two vinyl groups in butadiene is not very far from the hyperconjugation in propylene.

[3] Coulson, C. A., Chem. Soc. Symp. Bristol (1958); Chem. Soc. London (1958) 88.

The olefins were synthesized and their heats of combustion were determined. The results are summarized in Table 1, and the details are shown in Table 2.

TABLE 1.—*Heats of combustion of some cyclic olefins.*

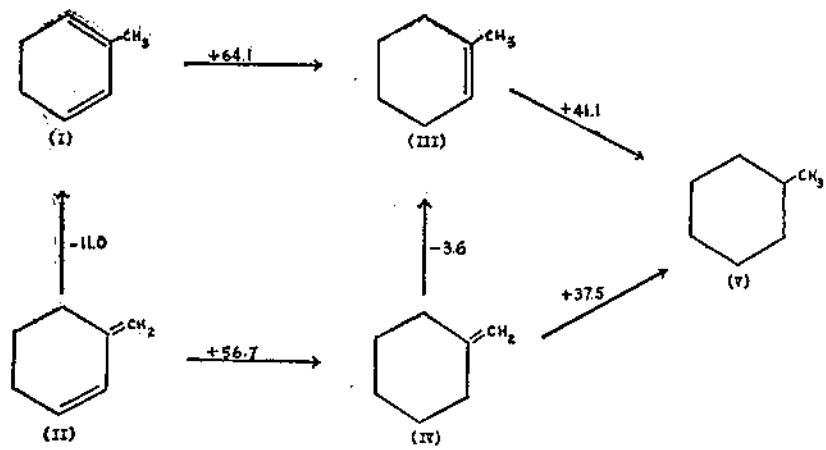
| Compound | $-\Delta H_c$ (kcal.mole$^{-1}$) |
|---|---|
| 1-Methyl 2,6-cyclohexadiene | 985.9 ± 0.9 |
| 1-Methylene 2-cyclohexene | 996.9 ± 0.4 |
| 1-Methylcyclohexene | 1050.0 ± 0.9 |
| Methylenecyclohexane | 1053.6 ± 0.9 |
| Methylcyclohexane | 1091.1 * |
| Cyclohexene | 891.9 ** |
| Cyclohexane | 936.9 * |

* Johnson, W. H., et al., Jour. Res. Nat. Bur. Stand. 36 (1946) 463.

** Kharasch, M. S., Ibid. 2 (1929) 359.

Since the compound with the smaller heat of combustion is the more stable isomer, its relative magnitudes or differences provide a way of evaluating the relative stability of any pair or set of isomers. Thus, from Table 1, the following may be noted:

1. 1-Methyl 2,6-cyclohexadiene (I) is (thermochemically) more stable than 1-methylene 2-cyclohexene (II) by about 11.0 kcal.mole$^{-1}$ and 1-methylcyclohexene (III) than methylenencylohaxane (IV)[‘] by about 3.6 kcal-mole$^{-1}$.




[‘] This agrees with the results from heats of hydrogenation found by Turner, R. B., and R. H. Garner [Jour. Am. Chem. Soc. 80 (1958) 1424] and corroborated by the free energy studies of Cope, A. C., et al., ibid. 81 (1959) 3153.

TABLE 2.—*Data on heats of combustion.*

| Compound | Mass | Temperature rise, °F | $-q(\emptyset CO_2H)$ | Corrections, BTU | | | $-\Delta E_c$ (Kcal.mole$^{-1}$) | $-\Delta H_c$ (Kcal.mole$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| | | | | −q (gelatin) | −q (acid) | −q (fuse wire) | | |
| | *gm* | | | | | | | |
| 1-Methyl 2, 6-cyclohexadiene | 0.2683 | 6.268 | 9200.02 | 1048.78 | 24.20 | 17.00 | 984.15 | 985.67 |
| | 0.2090 | 5.160 | 7570.27 | 1060.10 | 19.60 | 37.00 | 985.67 | 987.18 |
| | 0.2332 | 5.512 | 7988.51 | 1076.02 | 22.10 | 8.00 | 983.31 | 984.83 |
| | | | | | | | Average= 985.89±0.86 | |
| 1-Methylene 2-cyclohexene | 0.2294 | 5.297 | 7420.25 | 1131.20 | 19.00 | 29.00 | 994.87 | 996.38 |
| | 0.2013 | 5.123 | 7555.50 | 1100.50 | 19.50 | 39.00 | 995.74 | 997.27 |
| | 0.2030 | 4.902 | 7044.07 | 1027.78 | 19.60 | 40.00 | 995.48 | 996.99 |
| | 0.2420 | 5.264 | 7222.50 | 1005.96 | 20.10 | 29.00 | 995.56 | 997.05 |
| | | | | | | | Average= 996.92±0.38 | |
| 1-Methylcyclohexene | 0.1267 | 3.834 | 5764.34 | 1052.82 | 23.00 | 32.00 | 1049.72 | 1048.51 |
| | 0.1203 | 3.573 | 5293.85 | 1005.96 | 21.70 | 42.00 | 1048.20 | 1050.10 |
| | 0.1319 | 3.584 | 5034.73 | 1064.14 | 23.40 | 42.00 | 1048.00 | 1049.81 |
| | 0.1231 | 4.192 | 6642.88 | 1117.46 | 25.70 | 30.00 | 1049.96 | 1051.78 |
| | | | | | | | Average= 1050.05±0.89 | |
| Methylenecyclohexane | *0.1950 | 3.993 | 4819.93 | 1040.70 | 24.70 | 35.0 | 1050.42 | 1052.23 |
| | 0.1666 | 3.935 | 5205.20 | 1077.82 | 23.40 | 23.4 | 1052.96 | 1054.78 |
| | 0.2274 | 4.697 | 5852.10 | 1073.02 | 39.00 | 28.8 | 1052.01 | 1053.82 |
| | | | | | | | Average= 1053.61±0.93 | |

* Corrections for carbon = 13.756 BTU

2. The difference in the heats of combustion of cyclohexene and cyclohexane is 45.0 kcal-mole$^{-1}$. Since both cyclohexane and cyclohexene are almost strain-free,[5] then, about 45.0 kcal.mole$^{-1}$ represents the difference in the heats of combustion between any strain-free cycloalkane-cycloalkene pair. Any value that differs very much from this value would represent either strain or stabilization in the system.

Methylcyclohexane (V) may be shown to be strain-free[6] so that it provides a convenient basis for evaluating the presence or absence of added stability or strain in similar systems. The heats of combustion of 1-methylcyclohexene (III) and methylenecyclohexane (IV) differ from that of methylcyclohexane (V) by 41.1 and 37.5 kcal.mole$^{-1}$, respectively. These values are less than 45.0 kcal.mole$^{-1}$ by 3.9 and 7.5 kcal.mole$^{-1}$. These deviations, suggest the presence of strain in 1-methylcyclohexene (III)[7] and in methylenecyclohexane (IV)[8] in amounts proportional to the magnitude of these deviations.

The heats of combustion of 1-methylcyclohexene (III) and 1-methyl 2,6-cyclohexadiene (I) differ by 64.1 kcal.mole$^{-1}$ while methylenecyclohexane (IV) and 1-methylene 2-cyclohexene (II) differ by 56.7 kcal.mole$^{-1}$. The increase in values relative to 45.0 kcal.mole$^{-1}$ represents the onset of added stability due to the presence of an additional double bond located in conjugation to the first. Taking into account the presence of two double bonds in the di-olefins, the stabilization energies of 1-methyl 2,6-cyclohexadiene (I) and 1-methylene 2-cyclohexene (II) are 15.2 and 4.2 kcal.mole$^{-1}$, respectively.

It may be noted that in 1-methyl 2,6-cyclohexadiene (I), the conjugated system of double bonds is located entirely in the

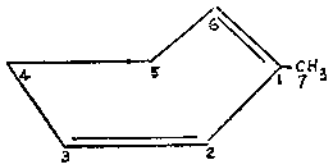
[5] Corey, R. J., and R. A. Sneen, Ibid 77 (1955) 2505.

[6] Methylcyclohexane may exist in the equatorial and axial forms; the former being strain-free (there being no angle strain and bond opposition forces), is preferred in the ground state.

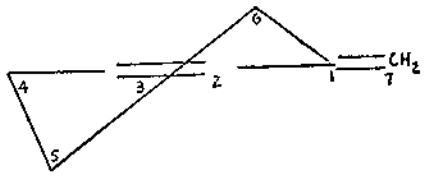
[7] Due to bond oppositions between the methylene group and the quasi-equa-equatorial substituent of the adjacent allylic carbon atom, also between the methyl-group and the olefinic hydrogen; the angle strain (in the absence of substituents) being about 1 kcal. [Pitzer, K. S. Science 101 (1949) 672] so that the introduction of a methyl group does not increase the strains appreciably.

[8] Due to bond oppositions between the methylene group and the equatorial substituents of the alpha-carbon atoms of the ring. Pascual, O. S. Jour. Philip. Pharm. Assoc. 46 (1959) 83.

ring but only partly[9] in 1-methylene 2-cyclohexene (II). This suggests that the greater stability of (I) compared to (II) is related to the ability of the system to permit the conjugation of the double bonds. The olefinic carbons of (I), being fully in the ring system, are held rigidly enough to permit better overlap of the p-orbitals. This may be evident if we examine the conformations of 1-methyl 2,6-cyclohexadiene (I) and 1-methylene 2-cyclohexene (II) which are illustrated in (VI) and (VII), respectively.




(VI)




(VII)

In (VI), the trigonal carbon atoms of the double bonds ($C_1$, $C_2$, $C_3$, and $C_6$) and the two ring carbon atoms attached to them ($C_4$ and $C_5$) must be in or in nearly the same plane due to the geometric requirements of the ethylene system. This planar arrangement of the ring carbon atoms permits a greater overlap of the p-orbitals of the trigonal carbon atoms.[10] In (VII), there are only three trigonal carbon atoms that are part of the 6-ring system ($C_1$, $C_2$, and $C_3$). These carbon atoms and the two carbon atoms attached to them ($C_4$ and $C_6$) must lie in nearly the same plane while the remaining ring carbon atom ($C_5$) may lie either above or below that plane.[11] The flipping of carbon atom ($C_5$) above and below the plane of the other ring carbon atoms due to rotation about the $C_4$–$C_5$ and $C_5$–$C_6$ carbon-carbon single bonds disturbs and probably prevents the maximum overlapping of the p-orbitals of the trigonal carbons $C_3$, $C_2$, $C_1$, and $C_7$. Thus, the absence of a ring framework to help the trigonal carbon atoms attain a planar structure which also minimizes (internal) rotation about

[9] Double bonds wherein one of the trigonal carbons is part of the ring (the other being outside the ring) are referred to as "semicyclic." Rodd, E. H. Chemistry of Carbon Compounds. Elsevier Publ. Co., Amsterdam, 1953. Vol. 2, part A, p. 145.

[10] The formation of a planar structure would distort severely the ring carbon-carbon bond angles from the preferred tetrahedral and trigonal values. Thus, the true structure of (VI) would depend on the balancing of these two forces.

[11] The unsubstituted cyclohexylidene structure is almost strain-free. See Burton, D. H. R., and R. C. Cookson. Quart. Rev. 10 (1956) 79.

the carbon-carbon single bonds and bond opposition forces between the methylene hydrogens of $C_7$ and the hydrogens of adjacent carbon atoms, may explain the large difference in stability not only between 1-methyl 2,6-cyclohexadiene (I) and 1-methylene 2-cyclohexene (II) but also between conjugated chain compounds and their analogous ring systems.

## EXPERIMENTAL

### PREPARATIONS OF THE CYCLIC OLEFINS

*a. 1-Methyl 2, 6-cyclohexadiene.*—146 gm (1.6 moles) of 1-methylcyclohexene was dissolved in an equivalent volume of $CCl_4$ and placed in a 3-neck flask equipped with a stirrer, a condenser and a dropping funnel. Bromine (250 gm, 1.56 moles) was added dropwise with stirring. After all the bromine had been added, the mixture was stirred for an hour at room temperature after which the solution was poured into iced water containing sodium bicarbonate. The lower layer was washed with sodium bicarbonate solution and dried with anhydrous $CaCl_2$. After removal of the $CCl_4$ by distillation, the product was added dropwise to a hot solution of 20 per cent KOH in methanol (142 gm KOH in 710 gm $CH_3OH$). The mixture was refluxed, poured into ice and extracted with ether. Distillation of the mixture yielded the olefin, b.p. 108°, $d_4^{26}$ 0.7140, $n_D^{30}$ 1.4714 (reported[12]: b.p. 108°, $n_D^{18}$ 1.4662).

*b. 1-Methylene 2-cyclohexene.*—2-Methylenecyclohexanol[13] was converted to the acetyl ester with acetyl chloride in dry pyridine in a 1:1.05:1.05 mole ratio. The acetate, b.p. 88 to 89° (20 mm) was pyrolyzed at 450°C in a Sargent Carius combustion apparatus, arranged vertically.[14] Distillation through a Vigreux column gave the olefin, b.p. 110°C, $d_4^{20}$ 0.8437, $n_D^{25}$ 1.4916.

*c. 1-Methylcyclohexene.*—98 gm (1.0 mole) of cyclohexanone was reacted with the Grignard reagent prepared from 142 gm (1.0 mole) of $CH_3I$ and 24 gm (1.0 mole) of magnesium turnings. Distillation yielded 62.3 gm (62 per cent yield) of 1-methylcyclohexanol, b.p. 52 to 53° (7 mm).

Dehydration of 62.3 gm of 1-methylcyclohexanol with 32 ml of conc. $H_2SO_4$ gave 23.0 gm (39 per cent yield) of 1-

[12] Zelinsky, N.D., and A. Gorky, Ber. 41 (1908) 2484.

[13] Prepared by LiAlH reduction of 2-hydroxymethylenecyclohexanone in anhydrous ether.

[14] Traynham, J. G., and O. S. Pascual, Jour. Org. Chem. 21 (1956) 1362.

methylcyclohexene, b.p. 109.5°, $n_D^{20}$ 1,4513 (reported[15]; b.p. 110°C, $n_D^{20}$ 1.4503).

*d. Methylenecyclohexane.*[16]—To the mixture of $K_2CO_3$ (135 gm), methyl alcohol (600 ml) and methyl iodide (270 gm), was added 33 gm of cyclohexylmethylamine. 51.0 gm (62 per cent yield) of N, N-dimethylcyclohexylmethylamine was obtained. This was dissolved in 150 ml of water and 46.4 gm (2.0 moles) of freshly prepared silver oxide was added. Distillation gave 4.7 gm (27 per cent) of methylenecyclohexane, b.p. 101°, $n_D^{20}$ 1.4519 (reported[17]: b.p. 102 to 103° (764 mm), $n_D^{20}$ 1.4523).

### DETERMINATION OF THE HEATS OF COMBUSTION

The olefins were burnt in a twin-valve Parr Adiabatic Oxygen bomb calorimeter whose water equivalent was checked with standard benzoic acid. An average value of 2441.91 ± 0.55 BTU deg$^{-1}$ was obtained. The samples were placed in gelatin capsules and Baker Primary standard reagent grade benzoic acid was used as catalyst.

### ACKNOWLEDGMENT

The authors hereby express their appreciation to Research Corporation (a Foundation) of New York City and to the University of the Philippines Natural Science Research Center for their generous financial support.

[15] Dreisbach. D. Physical properties of chemical compounds. Amer. Chem. Soc. Washington (1955) 490.

[16] For details, see thesis submitted by Zenaida A. Romasanta for the degree of B. S. in Chemistry to the Department of Chemistry, University of the Philippines (1959).

[17] Vogel, A. I., Jour. Chem. Soc. (1938) 1323.

# THE ABSOLUTE DETERMINATION OF NEUTRON FLUXES BY COINCIDENCE MEASUREMENTS

By JOSE O. JULIANO

*Philippine Atomic Research Center, Diliman, Quezon City*
(Received for publication, November 25, 1963.)

THREE TEXT FIGURES

In any reactor establishment the determination of the flux is very important because most, if not all, experiments are based on the accuracy and precision of the neutron flux of the reactor at the time of measurement. Neutron fluxes are usually measured by the activation of foils of known cross sections like gold, cobalt, etc. in a known flux and measuring the activities produced; and comparing these with the activities induced on the same or similar foils by the exposure to the unknown flux. In cases where no standard piles or sources of fluxes are present it is difficult to ascertain with great certainty the neutron flux of the reactor. Therefore, another method could be used; namely, the absolute determination of the neutron flux by coincidence measurement.(1)

Gold is readily available as 99.999 per cent Au-197. Its thermal-cross section follows the "$\frac{1}{v}$" relationship and is 98 barns at 2200 m/sec.(2) The product Au-198 has a convenient half-life of 2.7 days and there is no angular correlation between the beta particles and its most intense 412-kev transition. Furthermore, this 412-kev transition is very slightly converted. The decay scheme of Au-198 is well studied and is given in Fig. 1.(3)

## THEORETICAL CONSIDERATIONS

When Au-197 atoms are exposed to a thermal flux $\Phi_{th}$ the activity of Au-198 atoms produced by radiative capture is given by

$$A_{198} = N_{197}\,\sigma_{n\gamma}\,\Phi_{th}\,(1 - e^{-\lambda_{198}\,t})$$

where $A_{198}$ = the activity of the Au-198 atoms produced

$N_{197}$ = the number of Au-197 atoms in the target/cc

$\Phi_{th}$ = thermal flux, neutrons/cm$^2$-sec

$\sigma_{n\gamma}$ = Au − 197 (n, $\gamma$) Au-198 cross-section, 98 barns

$\lambda_{198}$ = decay constant of Au-198 $= \frac{0.693}{2.7}$ day$^{-1}$

$t$ = time of irradiation, days

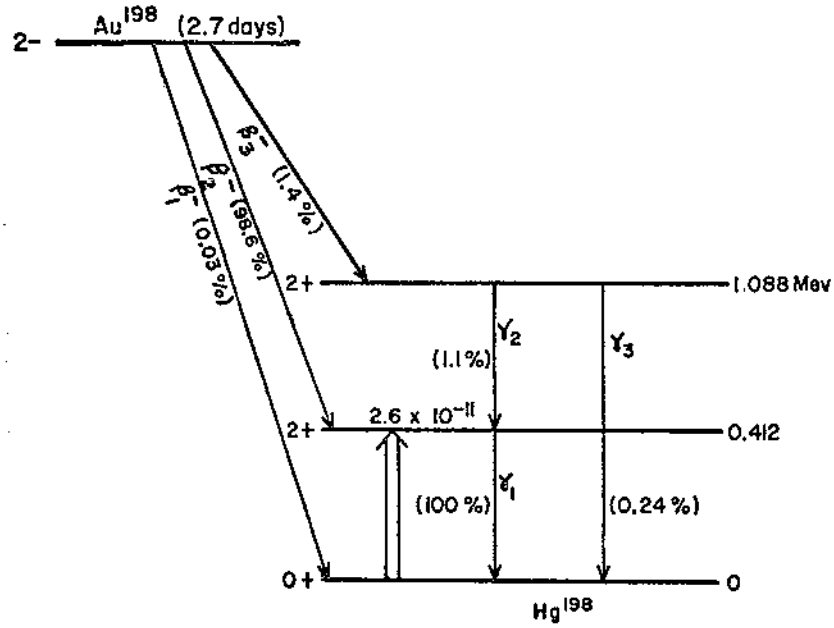



Fig. 1. Decay scheme of Au-198

Hence, the thermal flux $\Phi_{th}$ can be calculated if the absolute activity of Au-198 due to a pure-thermal flux can be measured.

Since not all fluxes are thermal, the resonance flux contribution to the Au-198 activity should be considered when measuring thermal fluxes. Making use of cadmium filters to remove the thermal flux contribution, the cadmium ratio, CdR, can be obtained experimentally where

$$\text{CdR} = \frac{\text{Activity of bare foil}}{\text{Activity of Cd-covered foil}};$$

the foils being irradiated under similar conditions. The total activity due to thermal and resonance fluxes is, therefore, related to the thermal flux activation by

$$\begin{pmatrix}\text{Thermal and resonance}\\ \text{flux activation}\end{pmatrix} = \begin{pmatrix}\text{thermal flux}\\ \text{activation}\end{pmatrix}\left(\frac{\text{CdR}}{\text{CdR}-1}\right)$$

Therefore the activity of the Au-198 in a Au-197 foil when exposed to a flux whose CdR is known can be expressed as:

$A_o$ = Disintegrations/sec =

$$\left(\frac{WN^*}{197}\right)\left(\frac{\sigma_{n\gamma}}{1.12}\right)\left(\frac{\text{CdR}}{\text{CdR}-1}\right)\left(1-e^{-\lambda_{198}t}\right)\Phi_{th}$$

where $A_o$ = absolute activity when removed from the reactor, dps
$W$ = weight of foil in grams
CdR = cadmium-ratio of foil
$\Phi_{th}$ = thermal flux (assumed Maxwellian)
$t$ = time of irradiation, days
$N^*$ = Avogadro's number, $6 \times 10^{23}$

In the above discussions it has been assumed that flux depression and self-shielding effects are negligible; furthermore, the temperature of the pile has been assumed to be 298°K. Once the exact value of $A_o$ is known the thermal flux $\Phi_{th}$ can be calculated.

The Au-198 atom decays mostly by a beta-group feeding the 412-kev transition which makes the use of $\beta-\gamma$ coincidence measurements very attractive in the determination of A, the absolute disintegration rate at any time after removal from the reactor.

If we let A = the absolute disintegration rate of Au-198, the number of beta particles, $N_\beta$, that will be detected by an anthracene crystal detector can be written as

$$N_\beta = \varepsilon_\beta A$$

where $\varepsilon_\beta$ is the efficiency of the beta detector which includes the geometry effect and all other factors. The number of 412-kev photons detected by a NaI (Tl) detector, $N_\gamma$, would similarly be expressed as

$$N_\gamma = \varepsilon_\gamma A$$

If the number of $\beta-\gamma$ coincidence, $N_{\beta\gamma}$, are calculated using the $N_\beta$ and $N_\gamma$ pulses the expected rate would be

$$N_{\beta\gamma} = \varepsilon_\beta \varepsilon_\gamma A$$

Therefore by rearranging the above equations the value of A, the absolute disintegration rate, can be calculated from

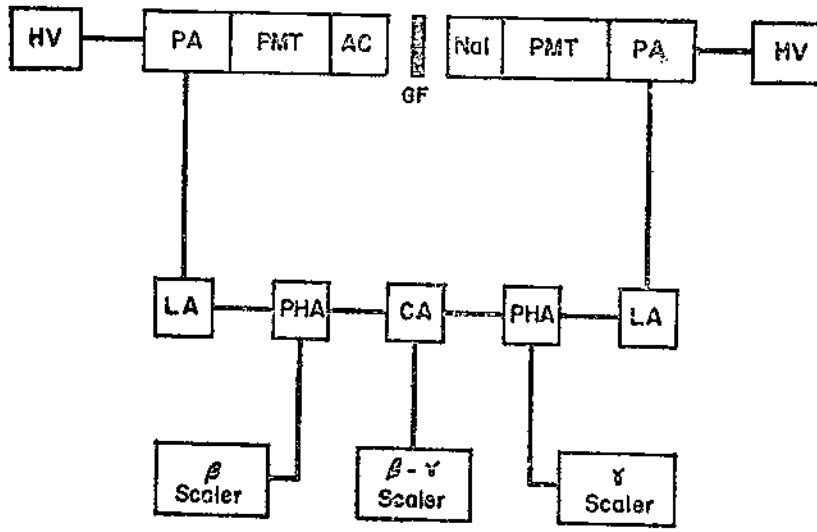
$$A = \frac{N_\beta N_\gamma}{N_{\beta\gamma}}$$

It is implied that chance coincidence, dead time and background corrections have been applied to the experimental values before they are used in this equation.

## EXPERIMENTAL

A beta-gamma coincidence circuit was set up using an anthracene crystal as the beta detector and a 3″ NaI(Tl) crystal as the photon detector. The pulses from these detectors were fed to their respective linear amplifiers, pulse-height analyzers, and scalers. The gamma counter was set to detect only the 412-kev photon while the beta detector was adjusted to count all pulses above noise. The pulses leaving the pulse-height-

analyzer were split into two, one of which was fed into a coincidence circuit with a resolving time of $1 \times 10^{-6}$ seconds; analyzer were split into two, one of which was fed into a coincidence circuit with a resolving time of $1 \times 10^{-6}$ seconds; the other was fed to a scaler. The output of the coincidence circuit was fed to a third scaler. A block diagram of the counting set-up is given in Fig. 2.




LEGEND:::

HV — HIGH VOLTAGE
PMT — PHOTOMULTIPLIER TUBE
PA — PREAMPLIFIER
LA — LINEAR AMPLIFIER
PHA — PULSE-HEIGHT ANALYZER
CA — COINCIDENCE ANALYZER
AC — ANTHRACENE CRYSTAL
NaI — NaI (Tl) CRYSTAL
GF — ACTIVATED GOLD FOIL

FIG. 2. Block diagram of coincidence set-up.

Two sets of gold foils (99.99 per cent pure) were irradiated in the University of Virginia standard pile for 9.73 days and sent to this laboratory for comparison in order to check the accuracy of the method. The foil data are given in Table 1.

A gamma spectrum of the Au-198 was made prior to the coincidence measurements using the gamma counter of the set-up. This was to check the settings and to make certain

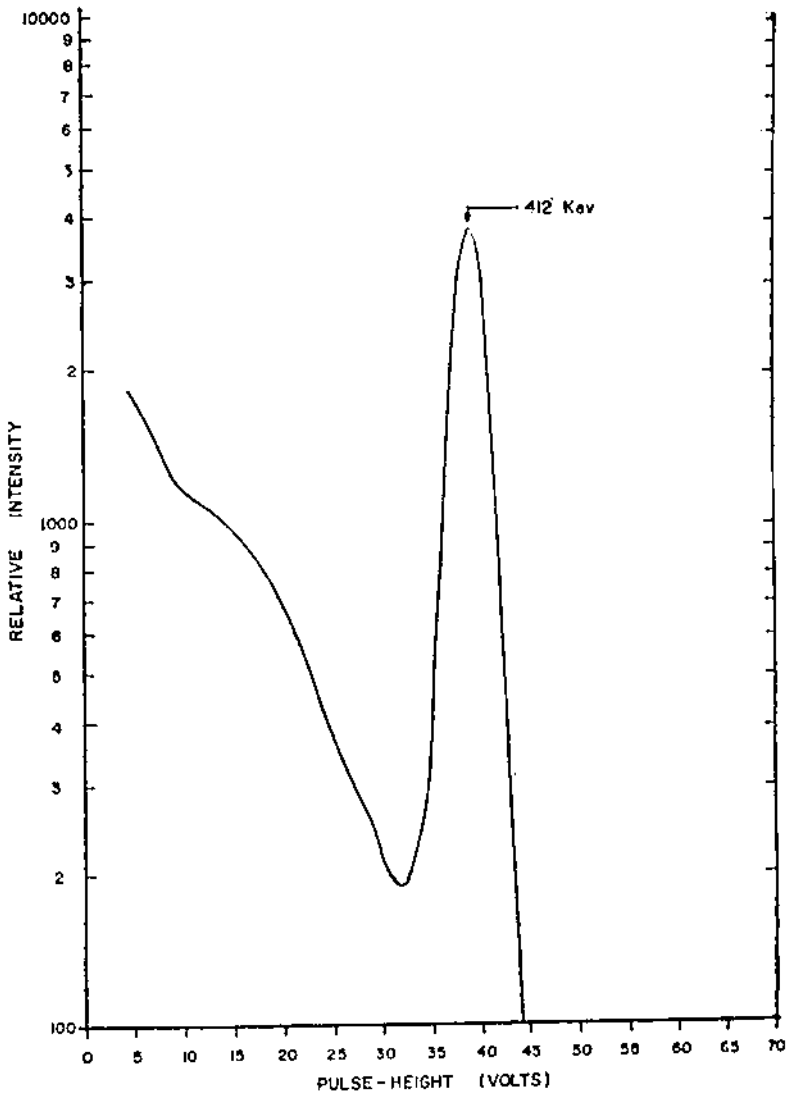



FIG. 3. Gamma spectrum of Au-198 foils.

the photopeak was the only one measured. The Au-198 gamma-ray spectrum is given in Fig. 3.

The four-activated gold foils were counted for $\beta$, $\gamma$, and $\beta - \gamma$ coincidence activities upon their arrival. However, owing to the low counting rate of the cadmium covered foils, only the bare foils were used in the measurements and the quoted cadmium ratios of the UVa standard pile were adopted. The results are given in Tables 2 and 3.

TABLE 1.—*Foil data.* (4)

| Foil number | Diameter | Weight | Cover condition | $\Phi_{th}$ (n/cm²/sec) | Cadmium ratio | Time (EDT) | |
|---|---|---|---|---|---|---|---|
| | | | | | | In | Out |
| | *Inch* | *gm* | | | | *July 22* | *August 1* |
| 1 | 0.5 | 0.1274 | Cadmium covered | $1.824\times10^{3}$ (±5.6%) | 6.094 | 16:25 | 10:00 |
| 2 | 0.5 | 0.1275 | Bare | $1.824\times10^{4}$ (±5.6%) | 6.094 | 16:25 | 10:00 |
| 3 | 1.0 | 0.7005 | Cadmium covered | $1.478\times10^{3}$ (±5.8%) | 6.220 | 16:25 | 10:00 |
| 4 | 1.0 | 0.7233 | Bare | $1.478\times10^{4}$ (±5.8%) | 6.220 | 16:25 | 10:00 |

TABLE 2.—*Results for the one-inch gold foil.*

| Time | | $N_\beta$ (per minute) | $N_\gamma$ (per minute) | $N_{\beta\gamma}$ (per minute) | Counting time (minutes) | A (per minute) | $A_o$ (per minute) |
|---|---|---|---|---|---|---|---|
| August 8 | 9:40 | 249 | 495 | 31.4 | 60 | 3,925 | 20,740 |
| August 12 | 8:20 | 98 | 157 | 11.4 | 60 | 1,347 | 19,590 |
| August 12 | 10:22 | 93 | 163 | 10.6 | 60 | 1,427 | 20,979 |
| August 12 | 12:35 | 92 | 163 | 11.5 | 60 | 1,304 | 19,825 |

Average = 20,284 ± 680

TABLE 3.—*Results for the half-inch gold foil.*

| Time | | $N_\beta$ (per minute) | $N_\gamma$ (per minute) | $N_{\beta\gamma}$ (per minute) | Counting time (minutes) | A (per) minute) | $A_o$ (per minute) |
|---|---|---|---|---|---|---|---|
| August 8 | 11:20 | 83 | 118 | 12.00 | 120 | 816 | 4,440 |
| August 8 | 13:30 | 81 | 120 | 11.92 | 120 | 815 | 4,525 |

Average = 4,483 ± 60

TABLE 4.—*Comparison of the University of Virginia standard pile and experimental results.*

| Foil diameter | Experimental | | | UVa Standard pile | | Difference |
|---|---|---|---|---|---|---|
| | $A_o$ | Standard deviation | $\Phi_{th}$ (n/cm²sec) | $\Phi_{th}$ (n/cm²sec) | Quoted accuracy | |
| *Inch* | | *Per cent* | | | *Per cent* | *Per cent* |
| 0.5 | 4,483 | ±1.3 | $1.988\times10^{3}$ | $1.824\times10^{3}$ | ±5.6 | 4.3 |
| 1.0 | 20,284 | ±3.4 | $1.613\times10^{4}$ | $1.478\times10^{4}$ | ±5.8 | 4.4 |

## CONCLUSIONS

The agreement between the experimental results and the $\Phi_{th}$ quoted values of the University of Virginia standard pile is shown in Table 4. The differences are within the errors of the measurements and also within the accuracy of the quoted thermal flux of the standard pile. It can be concluded that the beta-gamma coincidence measurements for absolute thermal flux determination is reliable, accurate and easy to perform and may be used to calibrate the flux of the Philippine Open Pool Reactor PRR-I.

## ACKNOWLEDGMENT

The author takes this opportunity to acknowledge the help of Dr. W. Reed Johnson and the University of Virginia for irradiating the foils in their standard piles.

## REFERENCES

1. MITCHELL, A. C. G. The Coincidence Method in K. Siegbahn (ed.). Beta and Gamma-Ray Spectroscopy, Interscience Publishers, Inc., New York (1955) 201.
2. Reactor Physics Constant Center, Reactor Physics Constants, Argonne Nat. Lab. Rep. ANL–5800 (1958) 524.
3. STROMINGER, D., J. M. HOLLANDER, and G. T. SEABORG. Table of Isotopes Revs. Mod. Phys. 30 (1958) 585.
4. LIM, G. Private communication (August 1, 1963).

031610—6

# CONTRIBUTIONS TO A REVIEW OF PHILIPPINE SNAKES, VI

## THE SNAKES OF THE GENUS OXYRHABDIUM

By ALAN E. LEVITON
*California Academy of Sciences, San Francisco 18, California*

(Received for publication, October 19, 1962.)

ONE TEXT FIGURE

The colubrid snakes of the genus *Oxyrhabdium* are restricted to the Philippines. To date no member of the genus has been taken from either the Sulu or Palawan Archipelagos, nor from Borneo or other islands of western Indonesia. Their possible discovery in the mountains of central and northern Borneo may well be anticipated. These are small burrowing snakes usually found under some sort of cover.

Two species are found in the Philippines, *O. modestum* and *O. leporinum.*

ACKNOWLEDGMENT

The writer wishes to thank the following persons for the privilege of examining specimens under their care: Mr. Charles M. Bogert and Dr. Richard Zweifel, American Museum of Natural History (AMNH); Mr. Neil Richmond, Carnegie Museum (CM); Dr. Robert F. Inger, Chicago Natural History Museum (CNHM); Dr. Ernest E. Williams, Museum of Comparative Zoology, Harvard University (MCZ); Dr. George S. Myers, Division of Systematic Biology, Stanford University (SU); and Dr. Doris M. Cochran, United States National Museum (USNM).

This work was supported partially by a grant from the American Philosophical Society.

### TERMINOLOGY

*Standard length:* distance from tip of snout to anal opening.

* : following locality listed under "Range" indicates sites from which specimens were examined.

6(2 + 3[28–38]) 4: caudo-dorsal reduction formula indicates that caudo-dorsal scales reduce from six to four by fusion of lateral rows 2 and 3 at level of 28 to 38 subcaudal plates.

**Genus OXYRHABDIUM Boulenger**

*Sténognathe* DUMÉRIL. (1853) 466, 468 (vernacular; defined in key and by brief description: "*S. modestus*, nobis," only included species.)

*Stenognathus* [*nec* Chaudoir (1843) Coleoptera] DUMÉRIL, BIBRON, and DUMÉRIL (1854) 503 (type species *Stenognathus modestus* Duméril, Bibron, and Duméril, by monotypy).

*Oxyrhabdium* BOULENGER (1893) 302 (substitute name [but not so stated] for *Stenognathus* Duméril, Bibron, and Duméril; type species designated herein as *Stenognathus modestus* Duméril, Bibron, and Duméril, 1854).

*Definition.*—Maxillary teeth 25 to 36, small and subequal; mandibular teeth subequal; head not distinct from neck, subacuminate anteriorly; inter nasals small; nostril in divided nasal; preoculars absent; both the elongate loreal and prefrontal border the orbit of the eye; eye moderate; pupil vertically subelliptic; anterior chin-shields greatly enlarged, subcircular or oval, separated from contact with mental by the first pair of lower labials; body cylindrical; scales smooth, in 15 longitudinal rows, not reducing in number on posterior part of body, without apical pits; tail short; subcaudals paired; hypapophyses present on posterior vertebræ; hemipenes deeply forked, spinose.

*Remarks.*—The presence of hypapophyses, deeply forked hemipenes, and numerous subequal maxillary teeth leads me to conclude that *Oxyrhabdium* is unrelated to any genus of burrowing or semi-burrowing colubrid snakes presently known from either Indonesia or the Malay Peninsula. I believe the similarities in the arrangement of head shields, smoothness of scales, reduction in length of the tail, and reduction in the size of the eye, shared in part with other genera of Indo-Malayan burrowing snakes (e.g. *Agrophis*, *Brachyorrhus*, *Oreocalamus*, and *Rabdion*) must be attributed to convergence among, otherwise, unrelated but morphologically adapted groups.

*Oxyrhabdium* is similar to *Xylophis*, a genus of small burrowing snakes from southern India. Agreement in characters between these genera may best be appreciated by comparing the definitions of the two. The above genus *Oxyrhabdium* is defined. The following definition of *Xylophis* was taken from

Smith [(1943) 341–342]; two items at the end have been added:

"Maxillary teeth small, 20–30, those in the middle a little larger than the others; head not distinct from neck; nostril between two small nasals, directed forwards and outwards; eye moderate, with rounded or vertically sub-elliptic pupil; loreal elongated, touching the eye; no preocular; anterior genials very large, in contact with the mental. Body cylindrical, scales smooth, without apical pits, in 13 or 15 rows throughout; ventrals rounded; tail short; subcaudals paired. Hypapophyses developed throughout the vertebral column." Prefrontal borders the orbit of the eye; hemipenes deeply forked, without spines.

The obvious differences between *Oxyrhabdium* and *Xylophis* are: (*1*) presence of spines in the hemipenes of *Oxyrhabdium,* but absent in *Xylophis;* (*2*) anterior genials not in contact with the mental in *Oxyrhabdium,* but in contact in *Xylophis;* and (*3*) maxillary teeth subequal in *Oxyrhabdium,* but a few in the middle of the series tend to be slightly enlarged in *Xylophis.* In addition, there are some differences between the two groups in size and spatial arrangement of the head shields.

The over-all structural similarity of the two genera strongly suggests a possible common ancestry. Further, their distributions, which are restricted to the zoogeographic 'blind alleys' at the peripheries of the Oriental Region, and the apparent absence of related genera in the intervening areas, suggest that they are relic genera.

Two species of *Oxyrhabdium* are recognized in the Philippines: *Oxyrhabdium modestum* from Basilan, Mindanao, Dinagat, Samar, Leyte, Bohol, and *Oxyrhabdium leporinum,* with two subspecies from Luzon, and the western Visayan Islands.

*Key to the species and subspecies of Oxyrhabdium Boulenger*

1a. Second upper labial not or but slightly in contact with loreal; usually 8 upper labials (rarely 7), fifth and sixth (rarely fourth and fifth) bordering orbit; some reddish color usually present in dorsal coloration; young with a distinct white nuchal collar, but no other markings ..... *O. modestum*

1b. Second upper labial always broadly in contact with loreal; usually 7 upper labials (rarely 6), fourth and fifth bordering orbit; no red in the dorsal color; young with a distinct nuchal collar and a series of narrow light crossbands on the body and tail (may or may not be present in the adults).

2a. Adults monochromatic above, without any trace of juvenile color pattern; ventrals plus subcaudals 192 to 230 (mean = 214.1). Luzon Island ..... *O. l. leporinum*

2b. Adults with narrow white crossbands and nuchal collar as in young; ventral plus subcaudals 221 to 235 (mean: (♂ + ♀) 228.7). Negros, Cebu and probably Panay island.

*O. l. visayanum.*

**OXYRHABDIUM MODESTUM** (Duméril, Bibron, and Duméril).

*Sténognathe modestus* DUMÉRIL (1853) 468.

*Stenognathus modestus* DUMÉRIL, BIBRON, and DUMÉRIL (1854) 504 (type loc: "Java"; syntypes [?in Paris Museum]; original description); PETERS (1861) 684 (Samar Island [Tubig]; considers *modestum* and *leporinum* as questioned synonyms)); (1872) 587 (*modestum* compared with *Stenognathus brevirostris* PETERS; considers type locality of *modestum* doubtful); JAN (1862) 28 (Giava" [= Java]; description); (1863) 35 (listed); (1865) Livr. 13, pl. 1, fig. 3; GÜNTHER (1873) 169 (considers *Rhabdosoma leporinum* Günther a synonym of *modestum*; questions type locality of *modestum*).

*Rhabdosoma modestum* GÜNTHER (1879) 77 (in part; Dinagat Island; listed).

*Geophis modestus* BOETTGER (1886) 106 (in part; distribution compiled; listed); CASTO DE ELERA (1895) 426 (distribution compiled; listed).

*Oxyrhabdium modestum* BOULENGER (1893) 392 (Dinagat Island; synonymy, description, counts of material examined); BOETTGER (1898) 32 (in part; Samar Island; listed); GRIFFIN (1911) 258 (in part; distribution compiled; listed in key); THOMPSON (1913) 214 (description of CAS 15235, anatomy; distribution compiled [includes Luzon, Samar, Leyte, Calamianes, Dinagat, and Mindanao]; source of data unknown); TAYLOR (1922a) 100, figs. 9a-c (Mindanao Island [Bunawan], Samar Island [Camp Gandara], Dinagat Island; synonyms, description, color in life, counts and measurements of material examined, ecological notes); (1922c) 295 (Mindanao Island [Zamboanga], Basilan Island, Leyte Island [Cabalian]; scutellation, counts and measurements of material examined, ecological notes); WERNER (1929) 44 (listed); LEVITON (1958) 289, fig. 1 (Basilan Island, Mindanao Island [Zamboanga City; Katipunan; Mt. McKinley, Bunawan], Dinagat Island, Leyte Island [Tarragona], Samar Island [Camp Gandara], Negros Island [Dumaguete]; synonymy, description, material examined, sexual dimorphism, ecological notes, distribution).

*Rhobdosoma leporinum* GÜNTHER (1858) 12 (in part; one of the types of R. *leporinum* Günther belongs to *O. modestum*); MÜLLER (1883) 283 (Mindanao Island; listed).

*Geophis schadenbergi* FISCHER (1885) 93, pl. 3, fig. 4 (type loc: "Süd-Mindanao"; syntypes in Dresden Museum; original description); BOETTGER (1886) 106 (distribution compiled; listed).

*Rangé*[1].—(Figure 1.) BASILAN*. BOHOL: Cantaub Barrio area*. DINAGAT. LEYTE: Cabalian*; Tarragona*. MINDANAO: Agusan Province (Bunawan*); Cotabato Province (Tatayan*, Saub*); Davao Province (Madaum*; Mt. McKinley*); Zamboanga Province (Zamboanga City*; Katipunan*). NEGROS: Negros Oriental Province (environs just north of Dumaguete*). SAMAR: Camp Gandara; Tubig.

*Material examined* (43).—BASILAN: CAS 60344. BOHOL: Cantaub Barrio (SU 19359). LEYTE: Cabalian (MCZ 25667); Tarragena (CNHM 42797). MINDANAO: Without exact locality [probably Bunawan, Agusan Province] (MCZ 25666); Agusan Province: Bunawan (CM 2272 and 2273, 2276 to 2279, 2281 to 2288; CNHM 22589, 53386; MCZ 22079, 20080); Cotabato Province: Saub Cotabato (MCZ 25665), Tatayan Cotabato (MCZ 25668 and 25669); Davao Province: Madaum, Tagum (CNHM 53384 and 53385, 53387 to 53389); Mt. McKinley (CNHM 63383). Zamboanga Province: Dicayo River, Katipunan (CNHM 68907); Zamboanga City (CAS 62038 and 62039). NEGROS: Negros Oriental Province: Dumaguete environs (SU 18224).[2] SAMAR: USNM 53531 and 53532, 122205 and 122206, 122213, 122216. PHILIPPINES: Without exact locality (CAS 15235).

Taxonomic notes: The distinctness of this species from its close relative, *O. leporinum,* has never been seriously questioned. Indeed, only Günther appears to have encountered serious difficulties in distinguishing between them. The syntypes of *Rhabdosoma leporinum* include one specimen of *leporinum* and one of *modestum.* In 1879, under the name *R. Modestum,* Günther includes one specimen of each species.

[1] Thompson [(1913) 214] includes Luzon and the Calamianes in the range of *O. modestum.* The former locality record probably results from confusion of this species with *O. leporinum.* The source for inclusion of the Calamianes in the range of *O. modestum* could not be determined. I do not believe the species occurs there.

Negros Island is included on the strength of a single specimen obtained by a student at Silliman University, Dumaguete, Negros Island, in 1951. Confirmation of the presense of a natural population of this species on Negros must await future collecting. I strongly doubt that the species will be found there.

[2] The same as in footnote 1.

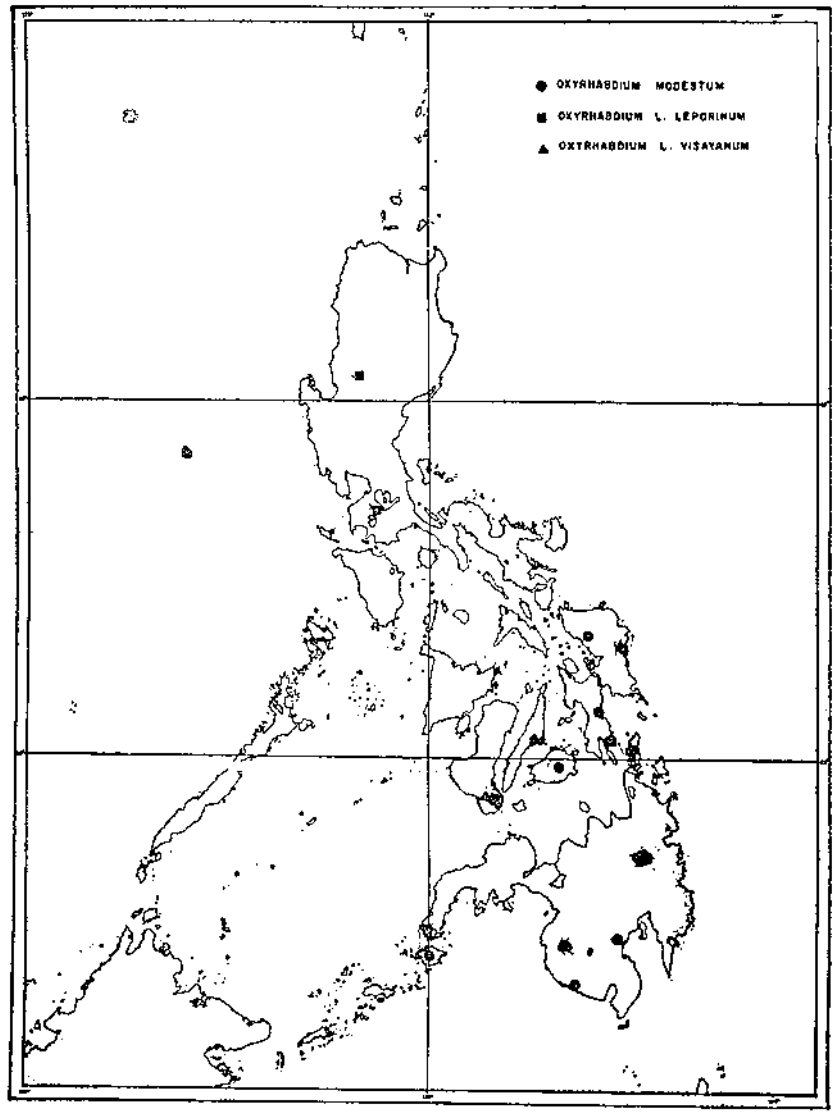



FIG. 1. *Distribution of the species of Oxyrhabdium in the Philippines.*

Comparison of Fischer's figures of *Geophis schadenbergi* with *O. modestum* leaves no doubt that the two are conspecific. There are 8 upper labials, the 5th and 6th shields border the eye, and the second shield is more broadly in contact with the nasal than the loreal.

TABLE 1.—*Summary of the variation in the number of ventral shields in Oxyrhabdium modestum.*

| Island | N | Male mean | Range | N | Female mean | Range |
|---|---|---|---|---|---|---|
| Basilan | | | | 1 | 168.0 | |
| Mindanao | 10 | 174.5 | 168–187* | 20 | 174.8 | 162–191 |
| Dinagat | | | | 1 | 177.0 | |
| Samar | 1 | 164.0 | | 5 | 168.0 | 164–170 |
| Leyte | 1 | 162.0 | | | | |
| Negros | | | | 1 | 168 .0 | |

* One young specimen not included had 153 ventrals which is likely abnormally low.

TABLE 2.—*Summary of the variation in the number of subcaudal shields in Oxyrhabdium modestum.*

| Island | N | Male mean | Range | N | Female mean | Range |
|---|---|---|---|---|---|---|
| Basilan | | | | 1 | 59.0 | |
| Mindanao | 11 | 63.9 | 60–70 | 20 | 57.9 | 53–64 |
| Dinagat | | | | 1 | 56.0 | |
| Samar | 1 | 60.0 | | 5 | 54.2 | 49–61 |
| Leyte | 1 | 66.0 | | | | |
| Negros | | | | 1 | 48.0 | |

TABLE 3.—*Summary of variation in head scutellation in Oxyrhabdium modestum.*

| | | | | | |
|---|---|---|---|---|---|
| Upper labials | 8(36)* | 7(3) | 7/8(2) | 8/7(2) | |
| Upper labials bordering eye | 5-6(35) | 4-5(5) | 4-5(1) / 5-6 | 5-6(2) / 4-5 | |
| Lower labials | 8(5) | 7(16) | 6(4) | 7/6(2) | 7/8(2) |
| Lower labials in contact with anterior genials | 5(19) | 4(9) | 4/5(3) | 4/5(1) | 5/4(1) |
| Loreal borders eye | Yes (38) | No (3) | | | |
| Postoculars | 1(1) | 2(36) | 1/2(1) | 2/3(3) | |

* Number in parentheses indicates number of specimen examined showing character.

The type locality of *Stenognathus modestus* was given as "Java." Peters [(1872b) 587], Günther [(1873) 169], and Taylor [(1922a) 100] regard this as doubtful, and Haas (1950) excludes it from his checklist of Indo-Australian snakes. That *Oxyrhabdium modestum* may occur on Java is highly unlikely, and I believe the locality data accompanying the holotype is erroneous. In view of this, I proposed [Leviton (1958) 291] that the type locality for *Oxyrhabdium modestum* be designated as Mindanao Island, Philippines. Until more is known about the intraspecific variability of this species, I see no reason to further restrict the type locality.

Differences in scale counts suggest that the populations of *O. modestum* on western Mindanao (Zamboanga) and Basilan Island, eastern Mindanao and Dinagat Island, and Samar and

Leyte islands may be distinguished from each other. However, based upon available material I do not regard these differences to be of sufficient magnitude to designate the populations as distinct subspecies.

*Diagnosis.*—A small snake, rarely exceeding 500 mm in standard length; one fourth or less of the dorsal suture of the second upper labial in contact with the loreal; usually 8 upper labials, the 5th and 6th bordering the orbit of the eye; hemipenes extend from the twelfth to twenty-first subcaudal plates; other than a light nuchal collar in the young, no light crossbands are present on body or tail in either young or adults. Standard length: (♂) 449 mm, (♀) 521 mm; tail length: (♀) 123 mm, (♂) 95 mm.

*Descriptive notes.*—Maxillary teeth 31 to 36 (–?40); internasals very small, about a fourth as large as prefrontals; prefrontals border orbit of eye; loreal elongate, usually bordering orbit of eye; preocular absent; 1 or 2 postoculars; temporals 1 + 2 + 3; 8 upper labials, rarely 7, the fifth and sixth, rarely fourth and fifth, bordering the orbit of the eye, less than one-third of the dorsal suture of the second upper labial in contact with loreal; dorsal scales in 15 longitudinal rows throughout; caudo-dorsal scales reduce as follows: 6 (2 + 3 [18–38] 4(1 + 2) [44–55]) 2; ventrals [153–] 162 to 186; subcaudals 48 to 67; anal plate single.

Hemipenes extend to twelfth to twenty-first subcaudal plates, forked at third plate; basal spines minute, then spines rapidly increase in size to between third and sixth subcaudal plates, and then they become gradually smaller posteriorly and finally are limited in posterior third of organ to two narrow bands of minute spines flanking the sulcus.

Color (in alcohol) light brown (tan) to deep reddish brown above, the color darkest along the mid-dorsal line; below lighter reddish brown to creamy yellow; upper labials colored as venter. In the young a distinctive white or cream nuchal collar is present. In individuals over 200 mm in standard length, this collar is no longer evident. Adults more or less monochromatic; no distinctive markings present.

*Color in life.*—Above dark iridescent lavender-brown, becoming lighter on sides; belly immaculate creamy yellow; top of head darker, bluish brown to lavender; labials cream color to yellow; under part of tail a muddy cream, with an indistinct zigzag line between subcaudals; edges of body scales darker, giving the appearance of an indistinct network over body. [Taylor (1922a) 101.]

*Sexual dimorphism.*—The males tend to have longer tails, a higher average number of subcaudals, and a lower number of ventrals than the females.

The tail length/standard length ratio for eight males ranges from 0.241 to 0.302 (mean = 0.264). The same ratio for 12 females ranges from 0.201 to 0.242 (mean = 0.220). Comparison of the tail lengths between sexes suggests the differences are significant.

The data for ventral and subcaudal counts are summarized in Tables 1 and 2. The differences in ventral counts between sexes are slight, but subcaudal counts appear to be subject to a marked dimorphism.

Sexual dimorphism is also evident in the point of reduction of the caudal scales from 6 to 4 longitudinal rows. In three males reduction took place between the thirty-first and thirty-fourth subcaudal plates; in one male reduction occurred at the thirty-eighth subcaudal plate. In each instance the second and third longitudinal scale rows fused to bring about the loss of one row. In six females reduction took place between the twentieth and twenty-eighth subcaudal plates; in one individual reduction occurred at the eighteenth and nineteenth subcaudal plates; and in one specimen reduction occurred at the tewnty-ninth and thirty-first subcaudal plates.

*Ecological notes.*—According to Taylor [(1922a) 103] specimens have been found on the forest floor under grass and leaves, and burrowing in among the roots of large fern trees. A single specimen collected at Abung-Abung, Basilan, was found at the base of a small palm tree [Taylor (1922c) 295]. Although most of the specimens for which data were available were collected near sea level, a single individual, CNHM 55383 was taken on Mt. McKinley, Mindanao Island, at an altitude of 6,300 feet.

Thompson [(1913) 215] recorded an earthworm of the family Perichoetidæ from the stomach of CAS 15235. Earthworms were also found in the stomachs of the specimens examined here. No other items were noted in their diets.

A single observation by Taylor [(1922a) 101] suggests that the species is oviparous. One female examined by him contained eggs; unfortunately no information is given concerning their size or number.

**OXYRHABDIUM LEPORINUM** (Günther).

*Rhabdosoma leporinum* GÜNTHER (1858) 12.

*Taxonomic notes.*—This species has been distinguished from *O. modestum* by the presence of 7 instead of 8 upper labials and by differences in the juvenile color pattern. Thought to have been confined to the highlands of northern Luzon [Taylor (1922a) 104], *O. leporinum* has since been collected at both low altitudes and on other islands of the Phlippine Archipelago.

Peters' description of *Stenognathus brevirostris* has been carefully compared with specimens of *O. leporinum* and with the descriptions of *O. leporinum* by Günther and Boulenger. The two nominal species are obviously conspecific.

Two populations of *O. leporinum* may be distinguished in the Philippines. These include the typical form found on Luzon Island and a recently discovered population on the islands of Negros and Cebu. Recognition of these populations is based upon differences in adult color pattern and in the total count of ventral plus subcaudal shield.

*Diagnosis.*—A small snake attaining a length of about 600 mm in standard length; at least one-third to one-half of the dorsal suture of the second upper labial is in contact with the loreal; usually 7 upper labials (rarely 6), the fourth and fifth (rarely third and fourth) shields bordering the orbit of the eye; hemipenes extending from seventh to tenth subcaudal plate; light crossbands present on body and tail of juveniles. Standard length: (♂) 548 mm, (♀) 610 mm; tail length: (♂) 125 mm, (♀) 104 mm.

*Descriptive notes.*—Maxillary teeth 25 to 33; snout pointed; rostral about as broad as deep, or slightly more broad than deep; internasals about a fourth or fifth as large as enlarged prefrontals; latter shields border orbit of eye; frontal longer than prefrontals, about twice as broad as supraoculars, shorter than parietals; nasal usually divided, posterior portion largest; loreal elongate, two to three times as long as deep, usually bordering orbit of eye; preoculars absent; postoculars 2; temporals 1 + 2 + 3; 7 upper labials, rarely 6, last shield largest, fourth and fifth shields, rarely third and fourth, bordering orbit, more than a third of dorsal suture of second shield in contact with loreal; mental small, more than twice as broad as deep; six or seven lower labials, four or five in contact with enlarged, subcircular to suboval ante-

rior chin shields; first pair of lower labials usually in contact at mid-line.

Dorsal scales in 15 longitudinal rows throughout; ventrals 158 to 184; subcaudals 33 to 62 (see Tables 4 to 6 and accounts of subspecies for geographic and sexual differences); anal plate single.

Color (in alcohol) above dark bluish brown, grayish brown, or deep brown, lighter on sides; below yellowish tan to whitish; upper labials colored as venter; dorsum may or may not be crossed by narrow whitish crossbands in the adults. Young individuals have a distinctive white or cream colored nuchal collar which is followed by a series of 35 or more narrow whitish crossbands on body and tail.

*Inter-island variation.*—The Negros-Cebu sample available for study differs from the Luzon sample most conspicuously in the adult color pattern. Individuals over 300 mm in standard length from Negros and Cebu retain the distinctive light crossbands which are characteristic of juveniles. Specimens of more than 300 mm in standard length from Luzon are monochromatic above and lack all traces of the juvenile color pattern.

The Luzon and Negros-Cebu samples also differ in the total of ventral plus subcaudal count. The ventral plus subcaudal count for 34 specimens from Luzon range from 192 to 230 (mean = 214.1); six specimens from Negros and Cebu range from 221 to 235 (mean = 228.7). Treating the sexes separately, the differences appear to be more pronounced: 17 Luzon males range from 210 to 225 (mean = 224.9); three males from Negros-Cebu range from 225 to 235 (mean = 228.0); 16 Luzon females range from 192 to 230 (mean = 209.3), and three females from Negros-Cebu range from 221 to 230 (mean = 226.3). Cursory inspection of the above data suggests that the differences are meaningful (Table 4).

**OXYRHABDIUM LEPORINUM LEPORINUM (Günther).**

*Rhabdosoma leporinum* GÜNTHER (1858) 12 (type loc: Philippine Islands; type in British Museum, London; original description; one of the two syntypes was shown to be a specimen of *O. modestum* [Boulenger (1893) 303]).

*Oxyrhabdium leporinum* BOULENGER (1893) 303, pl. 19, fig. 4 (Luzon Island; synonymy, description, counts of material examined; GRIFFIN (1911) 258 (distribution compiled; listed in key); TAYLOR (1922a) 103, text-fig. 10a-b (Luzon Island [Mount Santo Tomas; Baguio]; synonymy, description, color in life, counts and measurements of material examined); (1922b) 161,

164 (Luzon Island [camp approximately 30 km. north of Baguio; Mt. Makiling]; listed); (1922c) 296 (Luzon Island [near Haight's (Pauai); Baguio]; scutellation, counts and measurements of material examined); (1922d) 137 (Luzon Island [Mt. Makiling]; listed).

*Oxyrhabdium leporinum leporinum* LEVITON (1958) 296 (Luzon Island [Baguio]; distribution compiled; synonymy, description, sexual dimorphism, ecological notes).

*Stenognathus brevirostris* PETERS (1872) 586 (type loc: Philippine Islands; whereabouts of types unknown; original description [syntypes include one adult and one juvenile]).

*Geophis brevirostris* CASTO DE ELERA (1895) 425 (listed).

*Range.*—LUZON: Benguet Subprovince (Baguio *; Haights-in-the-Oaks *; slopes of Mt. Santo Tomas; Government Camp 30 km. north of Baguio); Laguna Province (Mt. Makiling *).

*Material examined* (*36*).—LUZON: without exact locality (CAS 62548, 62580; USNM 38046, 128123); Benguet Province: Haights-in-the-Oaks (USNM 38046); Baguio (AMNH 63378 to 63379, and 67094; GAS 61528; CM 2434, 2464; MCZ 776T to 778T[3], 780T, 1130T and 1131T, 1133T, 1135T, 1137T, and 1138T, unnumbered T, 25655 to 25664; SU 7267; USNM 128123). Laguna Province: Mt. Makiling (MCZ 25653 and 25654).

*Diagnosis.*—A small snake whose adults (considered as individuals greater than 300 mm in standard length) are monochromatic above, without any trace of crossbanded pattern typical of young individuals; ventrals plus subcaudals 192 to 230 (mean = 214.1).

*Sexual dimorphism.*—Males and females do not differ significantly in the numbers of ventral shields present but they do in subcaudal counts. There is complete overlap in ventral plus subcaudal counts too, (Table 4) but the differences between the means are large and clearly point to a difference between sexes in the total number of shields.

The sexes do differ most strikingly in the tail length/standard length ratio. The ratio for 14 males ranges from 0.189 to 0.280 (mean = 0.219); the range for 10 females is 0.150 to 0.197 (mean = 0.174).

[3] Numbers followed by "T" indicate E. H. Taylor field numbers. These specimens, in the possession of the Museum of Comparative Zoology, Harvard University, have not been given MCZ catalog numbers.

TABLE 4.—*Summary of the variation in the number of ventral plus subcaudal shields in Oxyrhabdium leporinum.*

| Island | N | Male mean | Range | N | Female mean | Range |
|---|---|---|---|---|---|---|
| Luzon | 17 | 224.9 | 210–225 | 16 | 209.3 | 192–230 |
| Negros | 2 | 228.0 | 225–231 | 2 | 229.0 | 228–230 |
| Cebu | 1 | 235.0 | ---------- | 1 | 221.0 | ---------- |

TABLE 5.—*Summary of the variation in the number of ventral shields in Oxyrhabdium leporinum.*

| Island | N | Male mean | Range | N | Female mean | Range |
|---|---|---|---|---|---|---|
| Luzon | 19 | 168.6 | 162–176 | 17 | 169.6 | 158–184 |
| Negros | 2 | 171.0 | 169–173 | 2 | 177.0 | 177 |
| Cebu | 1 | 173.0 | ---------- | 1 | 173.0 | ---------- |

TABLE 6.—*Summary of the variation in the number of subcaudal shields in Oxyrhabdium leporinum.*

| Island | N | Male mean | Range | N | Female mean | Range |
|---|---|---|---|---|---|---|
| Luzon | 18 | 49.4 | 37–57 | 16 | 40.4 | 33–46 |
| Negros | 2 | 57.0 | 56–58 | 2 | 52.0 | 51–53 |
| Cebu | 1 | 62.0 | ---------- | 1 | 48.0 | ---------- |

*Ecological notes.*—Taylor [(1922a) 104] states that specimens were dug up along an irrigation ditch and under rocks; he also obtained a single specimen crawling along an open forest path. All of the Taylor specimens were collected at moderate altitudes. Those from Baguio and Mount Santo Tomas were taken at elevation of about 2,000 meters; one specimen taken on Mount Makiling (= Mount Maquiling) was collected at an elevation of 780 meters. A single specimen in the Stanford collection was obtained by Dr. A. W. C. T. Herre near Baguio at an altitude of 5,000 feet.

Nothing is known of the breeding habits of this animal.

**OXYRHABDIUM LEPORINUM VISAYANUM Leviton.**

*Oxyrhabdium leporinum visayanum* LEVITON (1958) 299, fig. 2 (type loc: headwaters of Maite River, on slopes of Cuernos de Negros, Negros Oriental Province, Negros Island; type in Natutural History Museum, Standford University; original description, ecological notes).

*Range.*—CEBU: Antuwanga area*. NEGROS: Negros Occidental Province (Bagtik River Valley*); Negros Oriental Province (vicinity of Luzuriaga*).

*Material examined* (*6*).—CEBU: Antuwanga area, about 7 km. southwest of Cebu City (SU 17922, 18226). NEGROS: Negros Occidental Province: Bagtik River Valley, about 4 to 5 km. southwest of Dungga, 17 km. southwest of Toyum Barrio, Cauayan Town (SU 20810); Negros Oriental Province: Bonghong Sitio, Luzuriaga) CAS; 89796); near headwaters of Maite River, Cuernos de Negros (SU 18907, holotype); ridge on north side of Maite River, about 6 km. west of Luzuriaga (SU 18225).

*Diagnosis.*—A small snake, close to *Oxyrhabdium leporinum* from Luzon but differing in the adult stage by the presence of a series of 35 to 38 light bands, characteristic of the young of both populations, but absent from the adults of the typical form, and by the higher average number of ventrals plus subcaudals (221 to 235 as compared to 208 to 226 for the typical form).

*Sexual dimorphism.*—There is an obvious dimorphism in the number of subcaudal shields, the males having a higher number than the females (Table 6). The males also appear to have longer tails than females, based upon differences in the tail length/standard length ratio: the range for 3 males is 0.228 to 0.229; for 3 females the range is 0.160 to 0.204.

A difference in the position of reduction of the caudo-dorsal scales further suggests that the shape of the tails differs between sexes: (♂) 6 (2+3 [28–38]) 4 (1+2 [56–62]) 2; (♀) (2+3 [19–29]) 4 (1+2 [43–51]) 2.

*Ecological notes.*—According to Dr. Walter C. Brown, who was instrumental in obtaining all the specimens reported on here, these individuals were obtained from under logs and rocks and at the base of ferns. The specimens were collected at altitudes ranging from 1,500 to 3,000 feet. All were collected during December, February, March and April of 1954 and 1955.

Earthworms were found in the guts of two specimens.

## REFERENCES


BOETTGER, OSKAR. Aufzählung der von den Philippinen bekannten Reptilien und Batrachier. Mer. Senckenbergischen Naturf. Ges. (1886) 91–134.

BOETTGER, OSKAR. Katalog der Reptilien Sammlung in Museum der Senckenbergischen Naturforschenden Gesellschaft in Frankfurt-am-main. 2. Teil. Schlangen. Frankfurt-am-Main (1898) ix + 160 pp.

BOULENGER, GEORGE ALBERT. Catalogue of the snakes in the British Museum (Natural History). Volume 1, containing the families Typhlopidæ, Glauconiidæ, Boidæ, Ilysiidæ, Uropeltidæ, Xenopeltidæ, and Colubridæ aglyphæ, part. London (1893) xiii + 448 pp., 28 pls.

DUMÉRIL, AUGUST HENRI ANDRE. Prodrome de la classification des reptiles ofidiens. Mém. Acad. Sci. Inst. France 23 (1853) 399–536.

DUMÉRIL, AUGUST MARIE CONSTANT, GABRIEL BIBRON, and A. H. A. DUMÉRIL. Erpétologie générales ou histoire naturelle complète des reptiles. Paris 7 (1854) xvi + 780 + xii + 1536 pp.

ELERA, CASTO DE. Catálogo sistemático de toda la Fauna de Filipinas conocida hasta al presente, y á la vez et de la Colección zoológica del Museo de PP. Dominicos del Colegio-Universidad de Santo Tomas de Manila. Manila 1 (1895) viii + 701 pp. [Ophidiens, pp. 423–445.]

FISCHER, JOHANN GUSTAV. Ichthyologische und Herpetologische Bemerkungen. Part IV: Ueber eine Kollection von Amphibien und Reptilien von Mindanao. Jahrb. Hamburg wiss. Anst. 2 (1885) 80–81.

GRIFFIN, LAWRENCE EDMONDS. A check-list and key of Philippine snakes. Philip. Jour. Sci. § D 6 (1911) 253–268.

GÜNTHER, ALBERT CARL LUDWIG GOTTHILF. Catalogue of colubrine snakes in the collection of the British Museum. London (1858) xvi + 281 pp.

GÜNTHER, ALBERT CARL LUDWIG GOTTHILF. Notes on some reptiles and batrachians obtained by Dr. Adolf Bernhard Meyer in Celebes and the Philippine Islands. Proc. Zool. Soc. London (1873) 165–172, pl. 18.

GÜNTHER, ALBERT CARL LUDWIG GOTTHILF. List of the mammals, reptiles and batrachians sent by Mr. Everett from the Philippine Islands. Proc. Zool. Soc. London (1879) 74–79.

HAAS, C. P. J. DE. Checklist of the snakes of the Indo-Australian Archipelago (Reptiles, Ophidia). Treubia 20 (1950) 511–625.

JAN, GEORG. Enumerazione sistematica delle specie d'ofidi del gruppo Calameridæ. Arch. Zool. Anat. Fis., fasc. 1 2 (1862) 1–76, pls. 5–6, fasc. 2. pls. 17–18.

JAN, GEORG. Elenco sistematico, degli ofidi descritti e disegnati per l'Iconografia Generale. Milano (1863) vii + 143 pp.

JAN, GEORG. Iconographie générale des ophidiens. Paris and Milan (1865) [1860–1881], 52 Lvr.

LEVITON, ALAN EDWARD. A review of the Philippine snakes of the genus Oxyrhabdium (Serpentes: Colubridæ). Wasmann Jour. Biol. 15 (1958) 285–303.


031610——7

MÜLLER, FRITZ. Dritter Nachtrag zum Katalog der herpetologischen Sammlung des Basler Museums. Verh. Naturf. Ges. Basle 7 (1883) 274–299.

PETERS, WILHELM CARL HARTWEG. Eine Zweite Uebersicht [vergl. Monatsberichte (1859) 269] der von Hrn. F. Jagor auf Malacca, Java, Borneo und den Philippinen gesammelten und dem Kgl. zoologischen Museum übersandten Schlangen. Monatsb. Akad, wiss. Berlin (1861) 683–691.

PETERS, WILHELM CARL HARTWEG. Derselbe berichtete über drei neue Schlangenarten (Calamaria bitorques, Stenognathus brevirostris, und Hemigungarus gemianulis) von den Philippinen. Monatsb. Akad. wiss. Berlin (1872) 585–587.

SMITH, MALCOLM ARTHUR. Fauna of British India, Ceylon, and Burma, including the whole of the Indo-Chinese sub-region. Reptilia and Amphibia. Vol. III. Serpentes. London (1943) xii + 583 pp., 1 map.

TAYLOR, EDWARD HARRISON. The snakes of the Philippine Islands. Monog. Bureau Sci., Manila, No. 16 (1922a) 312 pp., 37 pls.

TAYLOR, EDWARD HARRISON. Additions to the herpetological fauna of the Philippine Islands. I. Philip. Jour. Sci. § D 21 (1922b) 161–204.

TAYLOR, EDWARD HARRISON. Addtions to the herpetological fauna of the Philippine Islands. II. Philip. Jour. Sci. § D 21 (1922c) 257–302.

TAYLOR, EDWARD HARRISON. Herpetological fauna of Mount Makiling. Philippine Agri. 11 (1922d) 127–139.

THOMPSON, JOSEPH CHEESMAN. Notes on serpents in the family Colubridæ. Proc. Acad. Nat. Sci. Philadelphia 65 (1913) 213–218.

WERNER, FRANZ. Uebersicht der Gattungen und Arten der Schlangen aus der Familie Colubridæ. III. Teil (Colubridæ). Mit einem Nachtrag zu den übrigen Familien. Zool. Jahrb., Syst. 57 (1929) 1–196.

# SYNONYMIES OF BARK BEETLES, XIII

## CONTRIBUTION TO THE MORPHOLOGY AND TAXONOMY OF THE SCOLYTOIDEA. 221

By KARL E. SCHEDL

*Lienz, Osttirol, Austria*

[Received for publication, April 6, 1963.]

ONE TEXT FIGURE

Mr. F. G. Browne recently published a paper, "Some Scolytidæ and Platypodidæ from the Oriental region," Philip. Jour. Sci. 89 (1960) 201–220, in which he described one new genus and a number of new species. Through the kindness of the Forest Products Research Institute, University of the Philippines, through Assistant Director Francisco N. Tamolang, and the Department of Entomology of the British Museum of Natural History, through Mr. R. T. Thompson, I was able to see the types and paratypes of *Acacisis borneensis* sp. nov., *Platypus franciæ* su. nov., *Trachyostus parvus* sp. nov., and *Diacavus quadridens* su. nov. and also one paratype of *Prowebbia subuculæ* sp. nov. By comparing this material with several types of my own collection, a few corrections have to be made.

### Genus PSEUDOACACICIS novum

On pages 202–204 two new species *Acacisis malayanus* and *Acacisis borneensis* have been described. The spelling "*Acacisis*" obviously is a misprint for "*Acacicis*" Lea, Proc. Roy. Soc. Vict. 22 (1910) 149. The three paratypes of *Acacisis borneensis* of the British Museum actually show all the more important external characters of *Acacicis* Lea, like the small anterior coxæ which are very widely separated from each other, the trapezoid outline of the pronotum, the nearly straight basal margin of the elytra, the submerged scutellum, and the rather sloping elytral declivity. The three-jointed antennal club also is very similar to that in the Australian genus *Acacisis*, but the funiculus, which is composed of seven joints in *Acacicis* consists of five joints only in *Acacisis borneensis* Browne. Differences of that kind have never been observed in the subfamily Hylesinæ, to which *Acacicis* belongs, and therefore we must regard *Acacisis borneensis* Browne as the type of another new genus, which so far known up to date

were from the Indo-Malayan region. We propose for this new genus the name *Pseudoacacicis*. Type specimens of the second species, *Acacisis malayanus* were not available; hence, its generic position cannot be established.

### Genus PROWEBBIA Browne

Examination of a paratype of *Prowebbia subuculæ* Browne clearly shows that the generic description of *Prowebbia* needs a correction as far as the antennæ are concerned. Comparing to F. G. Browne's statement, the antennal club is distinctly obliquely truncate as in many species of the genera *Ips* DeGeer and *Xyleborus* Eichhoff, with a fringe of hairs on the lower edge of the truncate face and a second one on the face itself very similar as this has been found in *Xelyberus bicornis* Schedl [Fed. Mal. St. Mus. 18 (1939) 349]. In genera with an actually flat antennal club the sutures or rows of hairs are curved in the opposite sense following more or less the apical margin of the antennal club.

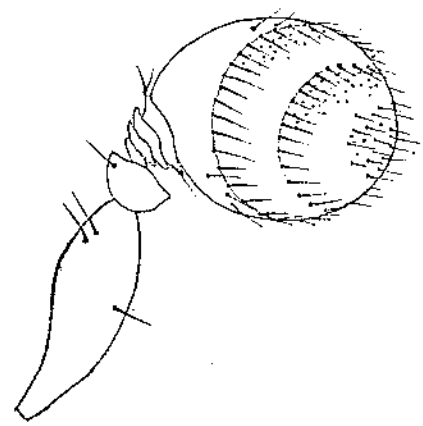


FIG. 1. Antennæ of *Prowebbia subuculæ* Browne.

*Platypus saltator* Schedl
Syn. *Trachyostus parvus* Browne

Comparison of the holotype and two paratypes of *Trachyostus parcus* Browne, loc. cit. p. 213 with the holotype of *Platypus (Crossotarsus) saltator* Schedl, Philip. Jour. Sci. 57 (1935) 480 proved that both species are perfectly identical so that *Trachyostus parvus* has to be withdrawn in favor of the much older *Platypus saltator* Schedl.

*Trachyostus* Schedl originally described as a subgenus to *Platypus* Herbts has been raised to the rank of a genus in Ann. Mus. Congo Belge, Sci. Zool. 56/8 (1957) 125 and should be used exclusively for the African group formerly designated as *Trachyosti obtecti* with the type *Platypus schaufassi* Strohm [Ent. Bl. 7/8 (1913) 161] while the *Trachyosti forficuli* should remain in the genus *Platypus*.

*Diacavus philippinensis* Schedl
Syn. *Diacavus quadridens* Browne

The holotype and three paratypes of *Diacavus quadridens* have been compared with the type of *Diacavus philippinensis* Schedl, Kol. Forstl. Mitt. 5 (1942) 216. As they agree in all respects *Diacavus quadridens* Browne has to be withdrawn in favor of *Diacavus philippinensis* Schedl.

In this connection it might be useful to draw attention to the fact that the number of pores along the basal margin of the pronotum is not perfectly constant. The holotype of *Diacavus philippinensis* shows a single pore on each side of the basal extremity of the median sulcus, in one of the paratypes we found one single pore on the left side while on the right side there do exist two pores of equal size. Similar variations in the number of pronotal pores are also known from other Platypodidæ.

# NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), LV

By CHARLES P. ALEXANDER
*Amherst, Massachusetts*

(Received for publication, February 11, 1963.)
FIVE PLATES

The present paper continues the consideration of the genus *Limonia* Meigen, the first part of which are treated species belonging to the single subgenus *Dicranomyia* Stephens. All materials discussed at this time are from India and were taken by the Swiss entomologist, Dr. Fernand Schmid, as has been discussed in various earlier papers that these treated species were secured by this remarkable collector. Parts XLIX and LIV of the present series of reports bear more particularly on the same subject and should be used in conjunction with this paper.

## THE SUBGENERA OF THE GENUS LIMONIA MEIGEN

The vast genus *Limonia* includes far more than 1,500 described species that are distributed in some 25 subgenera, almost all of which were considered as representing valid genera until about 1930. At that time it became evident that the group, while including many apparently diverse elements, actually represented a single genus and that it would be inadvisable to attempt to maintain the various entities as representing more than subgenera [Alexander (1930) dates in parenthesis are cited in the list of References at the conclusion of this paper]. With the subsequent discovery of many hundreds of additional species it became further evident that several of these supposedly valid subgeneric groups were very closely allied and were becoming increasingly difficult to define and maintain. In the light of what has transpired during these years it is seen that the statement by Osten Sacken (1887) was remarkably prophetic. This pioneer student of the Tipulidæ had anticipated the difficulties that might result from the indiscriminate proposal of supposed new genera that were based on weak or insufficient grounds. He writes:

> To these successors I am free to give a piece of advice, as the result of more than 30 years experience with Tipulidæ, and this is, not to

introduce new genera prematurely: Large accessions of new forms, or of variations of already well-known forms must be expected from as yet unexplored, principally tropical regions; but these accessions, although large, will be slow in coming. Do not introduce new genera for every slight deviation from a well-known type, because you would soon have no end of new genera, and a growing difficulty in discriminating between them. But do not hesitate to establish a new genus for a form which cannot be forced into any of the existing genera, and which shows distinctive characters in more than one organ of its body. Such forms are not very common. I had to give up several of the subdivisions to hastily adopted by me in 1868; but since that year, having, grown in experience, I found necessary to establish only four new genera of *Tipulidæ brevipalpi* (only one in the present paper).

In the present discussion no attempt is made to repeat various statements and arguments that have been advanced *pro* or *con* upon this subject by Alexander, Bergoth, Edwards, and some others and these should be consulted for a fuller appreciation of the subject. Papers that concern the extent and general features of the genus include Alexander (1929, 1950); Edwards (1938); on venation, Alexander (1927a, 1929b, 1934, 1950); Edwards (1938).

*Limonia* is one of the more variable of Dipterous genera, showing an unusual range and diversity of structure in various organs, especially the mouthparts, antennæ, eyes, wing venation, and structure of the male hypopygium. Thus, as concerns the mouthparts, there are species having these exceedingly short to barely evident, with the maxillary palpi reduced to a single segment (as in *Limonia citrofocalis* Edwards, of Borneo), to other groups (as *Geranomyia*, *Limonia*, s.s., *Zelandoglochina*) where the mouthparts, comprised essentially of the labial palpi, are greatly elongated, in cases being equal to or exceeding the remainder of the body. As regards the antennæ, this while primitively being a simple 14-segmented organ, in certain subgenera (*Rhipidia*, *Zelandoglochina*, and less evidently *Idioglochina*) has the antennal flagellum produced into long branches that formerly appeared to provide unusually strong generic or subgeneric characters. In both cases cited, of elongated mouthparts and branched antennæ, it was found that while these were relatively stable and usable as characters in a restricted faunal area, such as Europe, Japan or eastern North America, when the world fauna was considered such characters broke dawn almost competely. Thus in *Geranomyia*, with typically lengthened mouthparts, various

species were found where these were very reduced, being no longer than the condition considered as being normal for the typical subgenus *Limonia*, while also in the same subgenus the species were discovered that showed a surprising range in number of segments of the maxillary palpi from a single segment to four, again indicating virtual uselessness for taxonomic work in maintaining groups higher than the species. Further, as regards elongation of the mouthparts, attention is called in the present paper to certain form in the typical subgenus *Limonia* where in a single restricted group, some species have the rostrum very small and quite normal (as *hostilis* Alexander) to others of moderate length (*brachylabis* sp. nov.), to still others showing progressive elongation, with the maximum as presently known occurring in the fly described as *Limonia tanyrhyncha* sp. nov., where the mouthparts are fully one-third as long as the remainder of the body. In all other regards these various species of the *hostilis* group are typical members of the restricted subgenus *Limonia* and must be referred thereto despite the conspicuous development of the mouthparts. Plate 3, figs. 31, 32, and 33 of this paper may be consulted.

In the subgenus *Rhipidia*, the conspicuous branches of the male antennæ had appeared to provide unusually strong characters for maintaining the group as a valid genus. However, quite as in the preceding example, species later were discovered where the flagellar branches were more and more reduced until finally there remained scarcely any basis for maintaining the group even as a subgenus. In the males of many species of *Rhipidia*, and in virtually all females, the flagellar branches are reduced in size to present a subpectinate condition, with the lower face of an individual segment only slightly to scarcely produced. The range and nature of branching of the antennæ in *Rhipidia* has been discussed in considerable detail in another paper [Alexander (1950) 195–198].

The relative size of the compound eyes, in comparison with the width of the intervening anterior vertex, especially in the male sex, has been considered as possibly providing characters sufficient for generic or subgeneric separation (as *Atypophthalmus* Brunetti). In some species, the eyes of the male are very large, contiguous both above and beneath to produce a holoptic condition; in other species the eyes are somewhat smaller, reducing the anterior vertex to a narrow or even

capillary line about equal in diameter to a single row of ommatidia of the eye. In other species gradually widened vertices occur, in extreme cases these being very broad, the eyes correspondingly small (as *Melanolimonia* subgen. nov.).

The shape of the thorax, such as the elongation of the pronotum (*Telecephala*) or the elevation of the præscutum into an erect cone (*Conorhipidia*), formerly were believed to represent characters of value sufficient to separate groups worthy of a name. The halteres and legs similarly show a considerable range in their relative length. The halteres may be short, as normal for the family, or they may be greatly lengthened, particularly in the more delicate aerial species. The extreme length of the halteres as presently known appears to be found in *Limonia* (*Limonia*) *lindbergi* Nielsen (1962) of Afghanistan, where they are described as being longer than the combined head and thorax. The legs may be of a length about normal for the family or, in cases, may be greatly lengthened and correspondingly slender, though not attaining the extreme condition found in various Tipulinæ, as *Dolichopeza*, some *Tipula*, and others. The nature of toothing of the claws has been discussed by Alexander, Edwards, and others, and seems to provide at least supporting characters in any attempt to define subgenera.

The wings, including shape, venation, and trichiation of the veins and cells, provide what are probably the most important taxonomic characters in subgeneric division. A characteristic wing shape and great development of the prearcular field is found *Peripheroptera*, *Thrypticomyia*, *Euglochina*, and some others. The relative length of the subcostal vein, Sc, had long been held to be of importance in separating *Dicranomyia* from *Limonia*, s.s. [Alexander (1927a, 1929a, 1934, 1950); Bergroth (1915); Edwards (1938)] but its importance in this regard must be held in question, as is considered later in this present discussion. In some cases, as in *Discobola*, the presence of supernumerary crossveins in certain of the cells had been held to be of importance, leading to a belief that comparable significance and importance obtained in other cases where such supernumerary elements were present (as *Dapanoptera*, *Degeneromyia*, *Geranomyia*, *Gressittomyia*, *Laosa*, and *Neolimnobia*). The arrangement of the veins Sc and R in the vicinity of the stigma, as found especially in *Limonia*, *Orimarga*; Cylindrotominæ, Tipulinæ, has received much

consideration in papers by the writer and need not be repeated here [Alexander (1927a, 1927b, 1934b, 1950, and others)]. The number and distribution of macrotrichia of the wing veins appear to be of importance in defining genera and subgenera but it should be noted that in certain species the variation in number and arrangement of these trichia is greater than had formerly been believed [Alexander; Edwards (1938) 20–29].

The details of structure of the male hypopygium provide invaluable characters for the separation of species in *Limonia*, as well as in virtually all other genera in the family. However, despite striking modifications produced by outgrowths, efflorescenses and the like of the various parts, there remains a basic uniformity in all structures that only confirms our belief that all of these apparently diverse groups actually are closely allied and that a single genus is involved. Typical *Limonia* and some others have the dististyle single and simple in structure, a condition that Edwards (1938) considered as not necessarily being primitive, as it is in *Trichocera* and other generalized groups, but possible to have been secondarily reduced. The division of this simple dististyle into two parts, the so-called dorsal and ventral styles, as found in virtually all other members of the genus, has been discussed in several of the papers already cited. In *Dicranomyia*, *Geranomyia*, and many others, the beaklike extension of the ventral style known as the rostrum or rostral prolongation commonly bears two spines or spinoid setæ. The various positions or locations where these spines may occur have been discussed in detail in another paper [Alexander (1934a)]. The number of such spines ranges from one (most *Melanolimonia*) through three or more, reaching the extreme of about ten in certain *Rhipidia* and *Dicranomyia* (as *multispina* Alexander, of New Zealand, which perhaps may be referred to *Rhipidia*, based on this condition). It may be noted further that certain species presently placed in *Rhipidia* (the *rostrifera* group, with numerous species in eastern Asia) have only two rostral spines and may well be found to belong to some other subgeneric division, as *Dicranomyia*, despite the branched antennæ. Other structures of the male hypopygium and of the ovipositor have been discussed in some detail in other papers [Alexander (1950); Edwards (1938); and others].

From the preceding summary of characters available in *Limonia* it is seen that several groups as presently maintained are based on relatively minor and unimportant features and are becoming difficult to separate. Of particular concern are the many species in all parts of the world that have been placed almost indiscriminately either in typical *Limonia* or in *Dicranomyia*, based solely on the relative lengths of veins Sc and Rs [Alexander, several papers; Bergroth (1915); Edwards (1938); and many others]. An alternative to the use of this admittedly unsatisfactory venational feature would be to use characters found in the male hypopygium, in itself a further unsatisfactory procedure, since it leaves still in question the subgeneric position of the females of the various species. At present or until a more exhaustive study of the problem can be made I am leaving such questionable species unplaced as to subgenus, including several in the present report. It seems very probable that still other subgeneric groups will be found necessary when certain of these unassigned species become better known and are critically studied.

In the first general attempt to summarize the subgenera of *Limonia* [Alexander (1929a)] had listed all such groups known to that time, indicating their known distribution by biotic world regions, and providing a supplementary list of such names that appeared to represent synonyms. In succeeding years some additions to the list have been made while the distribution by regions has been extended. It seems desirable to provide a revised list of the apparently valid subgenera, with their distribution, and to indicate the synonymy. Dates here provided, when not in parenthesis, indicate the year of proposal and are not necessarily cited in the list of references at the conclusion of the paper.

**LIMONIA** Meigen, 1803. **Holarctic, Ethiopian, Oriental, Australasian**

(Synonyms—*Amphinome* Meigen, 1800; *Limnobia* Meigen, 1818; *Unomyia* Meigen, 1818; *Ataracta* Loew, 1850; *Limnomyza* Rondani, 1856; *Taphrophila* Rondani, 1856.)

**RHIPIDIA** Meigen, 1818. **Cosmopolitan (excluding New Zealand)**

(Synonyms—*Ceratostephanus* Brunetti, 1911; *Monorhipidia* Alexander, 1912; *Arhipidia* Alexander, 1912; *Conorhipidia* Alexander, 1914).

**DICRANOMYIA** Stephens, 1829. **Cosmopolitan**

(Synonyms—*Furcomyia* Meigen, 1818; *Glochina* Meigen, 1830; *Siagona* Meigen, 1930; *Numantia* Bigot, 1854; *Telecephala Pierrei*, 1921; *Tedotea* Santos Abreau, 1923).

**GERANOMYIA** Haliday, 1833. Cosmopolitan (excluding New Zealand)

(Synonyms—*Limnobiorhynchus* Westwood, 1835 (in part); *Aporosa* Macquart, 1838; *Plettusa* Philippi, 1865; *Tetraphana* Skuse, 1890; *Triphana* Skuse, 1890; *Monophana* Edwards, 1912; *Parageranomyia* Santos Abreu, 1923; *Pseudaporosa* Alexander, 1924; *Proaporosa* Alexander, 1924 (lapsus for the last).

**DISCOBOLA** Osten Sacken, 1865. Holarctic, Neotropical, Oriental, Australasian

(Synonym—*Trochobola* Osten Sacken, 1869)

**PERIPHEROPTERA** Schiner, 1866. Neotropical

**LIBNOTES** Westwood, 1876. Eastern Palaearctic, Ethiopian, Oriental, Australasian (excluding New Zealand).

**DAPANOPTERA** Westwood, 1881. Australasian, especially Papuan.

**THRYPTICOMYIA** Skuse, 1890. Eastern Palaearctic, Ethiopian, Oriental Australasian (excluding New Zealand).

**GONIODINEURA** van der Wulp, 1895. Oriental, Australasian (excluding New Zealand)

**ZALUSA** Enderlein, 1906 (validity uncertain). Neotropical, extreme south.

**ATYPOPHTHALMUS** Brunetti, 1911. Eastern Palaearctic, Ethiopian, Oriental, Australasian (excluding New Zealand).

**METALIMNOBIA** Matsumura, 1911. Holarctic, Ethiopian, Oriental

**DOANEOMYIA** Alexander, 1921. Oriental, Australasian (excluding New Zealand).

**EUGLOCHINA** Alexander, 1921. Ethiopian, Oriental, Australasian (excluding New Zealand).

**IDIOGLOCHINA** Alexander, 1921. Marine, Pacific and Indian Oceans—all regions.

**PSEUDOGLOCHINA** Alexander, 1921. Ethiopian, Oriental, Australasian (excluding New Zealand).

**ALEXANDRIARIA** Garrett, 1922. Nearctic; Eastern Palaearctic, Oriental and Australasian, these probably in error.

**ZELANDOGLOCHINA** Alexander, 1924. Neotropical (Chile), Australasian (New Zealand).

**GRESSITTOMYIA** Alexander, 1936. Australasian (Fiji).

**LAOSA** Edwards, 1926. Palaearctic, Oriental, Australasian (excluding New Zealand).

**NEOLIMNOBIA** Alexander, 1927. Neotropical.

**GRESSITTOMYIA** Alexander, 1936. Oriental (Hainan).

**DEGENEROMYIA** Alexander, 1956. Australasian (Fiji).

**SIVALIMNOBIA** Alexander (in press). Eastern Palaearctic, Oriental

**MELANOLIMONIA** subgen. nov. Holarctic, Oriental

**LIMONIA (LIMONIA) DEVATA** sp. nov. Plate 1, fig. 1; Plate 2, fig. 27.

Belongs to the *globithorax* group; general coloration of thorax yellowish brown; rostrum and palpi greatly reduced; legs brown; wings strongly infuscated, stigma lacking, Rs long; male hypopygium with ventromesal lobe of basistyle very long, gradually narrowed outwardly, terminating in a cylindrical point; genapophysis with mesal-apical lobe long and slender.

*Male.*—Length, about 4.5 millimeters; wing, 5; antenna, about 1.0.

Rostrum and palpi greatly reduced. Antennæ black; flagellar segments short-oval, with abrupt slightly paler apical pedicels; terminal segment smaller than the penultimate. Head dark brown; anterior vertex relatively broad, nearly twice the diameter of the scape.

Pronotum dark brown. Mesothorax almost uniformly yellowish brown, including four scarcely differentiated præscutal stripes. Halteres dark brown, base of stem restrictedly yellow. Legs with coxæ and trochanters obscure yellow; remainder of legs medium brown. Wings (Plate 1, fig. 1) strongly infuscated, unpatterned, stigma lacking; veins brown. Venation: Sc long, $Sc_1$ ending about opposite two-thirds the long straight Rs, $Sc_2$ longer than the transverse $Sc_1$; free tip of $Sc_2$ far basad of $R_2$, the element $R_1$ being more than three times $R_2$; cell 1st $M_2$ rectangular, subequal to vein $M_3$; m-cu shortly beyond fork of M.

Abdomen, including hypopygium, dark brown. Male hypopygium (Plate 2, fig. 27) with the tergite, *t*, short-transverse, very gradually narrowed outwardly, posterior border broadly thickened, shallowly emarginate, lobes obliquely truncated. Basistyle, *b*, with ventromesal lobe very long, gradually narrowed outwardly, terminating in a slender cylindrical point; vestiture near apex of lobe including short retrorse setulæ additional to the scattered long setæ. Dististyle, *d*, subequal in area to body of basistyle, suboval, the outer half more narrowed, apex obtuse; a dense linear group of retrorse setæ on outer half. Gonapophysis, *g*, with mesal-apical lobe long and slender, near outer end more blackened, the acute tip gently curved. Ædeagus, *a*, terminating in two slender divergent blades, surface with numerous scattered slender setæ.

*Habitat.*—Assam.

Holotype, Male, Mawja, Khasi-Jaintia, altitude 550 feet, March 30, 1960 (*Schmid*).

*Limonia* (*Limonia*) *devata* is quite distinct from other members of the *globithorax* group in the hypopygial structure, especially the basistyle and gonapophysis. Other members of the group, additional to *L.* (*L.*) *globithorax* (Osten Sacken), include *L.* (*L.*) *canis* Alexander, *L.* (*L.*) *cynotis* Alexander, *L.* (*L.*) *globulithorax* Alexander, *L.* (*L.*) *melas* Alexander, and probably also *L.* (*L.*) *cneprosa* Alexander.

LIMONIA (LIMONIA) ACINACIS sp. nov. Plate 1, fig. 2; Plate 2, fig. 28

Size medium (wing of male 6.6 millimeters); general coloration of body brown, abdomen darker; antennæ relatively long; wings uniformly light brown, stigma darker brown, $Sc_1$ ending shortly beyond midlength of Rs; male hypopygium with body of dististyle very small, the prolongation very long and slender; apex of ventromesal lobe of basistyle shallowly bilobulate; gonapophysis with mesal-apical lobe a slender blackened rod.

*Male.*—Length, about 5.8 to 6 millimeters; wing, 6.6 to 7; antenna, about 1.3 to 1.4.

Rostrum and palpi black. Antennæ black, relatively long; basal flagellar segments short-oval, the outer ones more elongate, all longer than their verticils; terminal segment longest, abruptly narrowed on outer fifth. Head dark brown; anterior vertex reduced to a narrow stripe, scarcely wider than a single row of ommatidia.

Prothorax dark brown. Mesonotum medium brown, polished, scarcely patterned. Pleura medium brown, the dorsal pleurites darker to produce a diffuse darker stripe. Halteres with stem dusky, very narrowly yellowed at base, knob dark brown. Legs with coxæ brown, fore pair darker; trochanters brownish yellow; remainder of legs broken. (Wings Plate 1, fig. 2) uniformly light brown; stigma short-oval, darker brown; veins brown. Longitudinal veins beyond cord with macrotrichia, including also most of Rs and outer end of M, lacking on basal section of $Cu_1$ and the anals. Venation: Sc long, ending about opposite three-fifths Rs, $Sc_2$ near its tip; free tip of $Sc_2$ and $R_2$ in transverse alignment; cell 1st $M_2$ subequal to distal section of $M_{1+2}$; m-cu at fork of M.

Abdomen, including hypopygium, dark brown. Male hypopygium (Plate 2, fig. 28) with the tergite, *t*, transverse, tapering laterally into slender rods, cephalic border very strongly produced, subtriangular; apical lobes low, each with seven or eight long setæ. Basistyle, *b*, at least four to five times as extensive as the dististyle; ventromesal lobe shallowly bilobulate at apex, the obtuse lobules with numerous setæ. Dististyle, *d*, with body very small, in area subequal to the lobe of the basistyle, provided with long setæ; rostral prolongation a gently curved elongate rod, narrowed at tip into an acute point, the prolongation about twice as long as the body of style, provided with a few long scattered setæ almost to tip. Gona-

pophysis, *g*, with mesal-apical lobe a slender blackened rod, the tip subacute. Ædeagus broad, terminating in two divergent points into which the genital tubes open.

Holotype, Male, Lachung, altitude 8,610 feet, July 9, 1959 (*Schmid*).

*Habitat.*—Sikkim.

Holotype, male, Lachung, altitude 8,610 feet, July 9, 1959 (*Schmid*).

Paratype, male, Zema, altitude 8,900 feet, June 11, 1959 (*Schmid*).

*Limonia* (*Limonia*) *acinacis* is generally similar to certain other small and medium sized regional members of the subgenus having unpatterned wings, such as *L.* (*L.*) *bilobulifera* Alexander, *L.* (*L.*) *decurvans* Alexander, *L.* (*L.*) *machidai* (Alexander), *L.* (*L.*) *tagax* Alexander, and others. It differs from all such species in the very small dististyle with the rostral prolongation greatly produced.

LIMONIA (LIMONIA) BIFARIA sp. nov. Plate 1, fig. 3; Plate 2, fig. 29.

Size small (wing of male up to 6 millimeters); thorax yellow, præscutum and dorsal pleura patterned with dark brown; antennæ black, flagellar segments short-oval with short abrupt apical pedicels; legs medium brown; wings strongly infuscated, stigma slightly darker brown, nearly circular; Sc ending about opposite two-thirds to three-fourths Rs; male hypopygium with the ventromesal lobe of basistyle bilobed; dististyle with body trilobed; gonapophysis with mesal-apical lobe a small acute spine.

*Male.*—Length, about 4.8 to 5 millimeters; wing, 5.5 to 6; antenna, about 1.1 to 1.2.

Rostrum black, labial palpi more yellowed, maxillary palpi black. Antennæ relatively long, black throughout; flagellar segments short-oval, with short abrupt apical pedicels, verticils shorter than the segments; terminal segment nearly twice the penultimate. Head brownish gray; eyes with coarse ommatidia, almost contiguous above.

Pronotum small, dark brown. Mesonotal præscutum brownish yellow, with a broad dark brown central stripe, scutal lobes similarly darkened; posterior sclerites of notum brown, more yellowed laterally. Pleura yellow, with a broad diffuse dorsal stripe in the type, ventral sternopleurite extensively paler brown; the Kumaon paratype has the pleura more uniformly yellowed. Halteres dark brown, base of stem narrowly

yellowed. Legs with coxæ yellow, the fore pair darker; trochanters yellow; remainder of legs medium brown; claws with a long slender basal spine: Wings (Plate 1, fig. 3) strongly infuscated, stigma nearly circular, slightly darker brown; veins brown. Venation: $Sc_1$ ending about opposite two-thirds to three-fourths Rs, $Sc_2$ either near its tip or slightly removed, cell 1st $M_2$ subequal to distal section of $M_3$; m-cu close to fork of M, in cases up to about one-fifth its length beyond.

Abdominal tergites and hypopygium dark brown, basal sternites slightly more yellowed. Male hypopygium (Plate 2, fig. 29) with the tergite, *t*, transverse, posterior border convexly rounded, slightly to scarcely emarginate; cephalic margin of tergite strongly produced into a triangular point; setæ sparse but long and conspicuous. Basistyle, *b*, with ventromesal lobe conspicuously notched at apex to appear bilobed, each lobe with relatively sparse long setæ. Dististyle, *d*, with body trilobed, the outer part of body with two larger lobes, the third more mesal in position at base of the long sicklelike rostral prolongation which narrows gradually into an acute point. Gonapophysis, *g*, with mesal-apical lobe a small acute spine, its tip blackened.

*Habitat.*—Assam, Kumaon.

Holotype, male, Sirhoi Kashong, Manipur, Assam, altitude 7,500 feet, July 12, 1960 (*Schmid*). Paratopotype, male, July 11, 1960. Paratype, 1 male, Kanol, Pauri Garhwal, Kumaon, altitude 8,530 feet, August 19, 1958 (*Schmid*).

In the hyopygial structure, as the lobing of the basistyle and dististyle, the present fly suggests *Limonia* (*Limonia*) *bilobulifera* Alexander of the Philippines, differing conspicuously in the venation and in all details of the hypopygium.

**LIMONIA (LIMONIA) HOSTILIS** Alexander. Plate 2, fig. 30.

*Limonia* (*Limonia*) *hostilis* ALEXANDER, Philip. Jour. Sci. 51 (1933) 533–534, plate 1, fig. 14 (venation). Philip. Jour. Sci. 58 (1935) 413–414.

The species was described from a specimen taken near Yien-Long-Shien, China-Tibet border, altitude 13,000 to 15,000 feet, August 3–6, 1930 (*Graham*).

Other materials have greatly extended the range of this particularly interesting fly.

Mount Omei, Szechwan, China, altitude 10,800 to 11,000 feet, August 16–20, 1934 (*Graham*).

Adung Valley, northeastern Burma, altitude 12,000 feet,

August 5, 1931 (*F. Kingdon Ward-Lord Cranbrook*); British Museum (Natural History).

Gey, Sikkim, altitude 12,000 feet, in *Rhododendron* association, May 20, 1959 (*Schmid*).

Bitzal Nullah, western Karakorams, Kashmir, altitude 14,000 feet, September 2, 1934 (*Miss Vivien Hutchinson*).

The hypopygium has not been described or figured. Male hypopygium (Plate 2, fig. 30) with the posterior border of tergite, *t*, very convexly rounded, the plate almost semicircular in outline; posterior margin narrowly thickened and sclerotized, with four low lobes, the larger intermediate pair separated by a small U-shaped emargination. Basistyle, *b*, with ventromesal lobe very extensive but not freely projecting, flattened and applied to the entire mesal face of style. Dististyle, *d*, only about one-fourth the size of the basistyle, not heavily blackened or sclerotized, gradually narrowed into a long slender point or beak. Gonapophysis, *g*, with mesal-apical lobe greatly reduced in size, triangular in outline. Ædeagus broad, especially at base, terminating in two small lobes; surface with a linear row of delicate setulæ.

*Limonia* (*Limonia*) *hostilis* may be identical with the still undescribed *L.* (*L.*) *latipennis* Edwards, a manuscript name that has appeared in print [Alexander, Philip. Jour. Sci. 51 (1933) 534]. It was the first described species of what now are known to represent a group of superficially similar forms living at high altitudes in the mountains of southern and eastern Asia. These species show strong hypopygial characters but are of interest primarily in the mouthparts, particularly the unusual range in development of the terminal segment of the labial palpus, as was briefly discussed in the introduction to the present paper. These structures are short and inconspicuous in *L.* (*L.*) *hostilis*, *L.* (*L.*) *brachylabis* sp. nov., and probably others, of intermediate length in *L.* (*L.*) *stenolabis* sp. nov., while reaching the extreme as known in *L.* (*L.*) *tanyrhyncha* sp. nov. (compare figures 31, 32, 33). It would appear that this modification of the mouthparts is an adaptation to feeding on nectar of various high alpine flowers, a condition obtaining in the allied subgenus *Geranomyia*. The recently described *L.* (*L.*) *lindbergi* Nielsen, briefly mentioned in the present introduction because of the unusual development of the halteres, may belong to this same group of species rather than being related to *L.* (*L.*) *macrostigma* Schummel, as was believed by Nielsen.

LIMONIA (LIMONIA) BRACHYLABIS sp. nov. Plate 1, fig. 4; Plate 3, figs. 31, 34.

Allied to *hostilis;* general coloration of body brown; terminal segment of labial palpus short and broad, the length not exceeding four times the diameter and about one-half as long as the maxillary palpus; legs dark brown, tips of femora concolorous; wings strongly infuscated, stigma only faintly indicated, costal border and axillary angle slightly darkened; $Sc_1$ ending about opposite three-fourths Rs, $Sc_2$ near its tip; male hypopygium with body of dististyle oval, with very long setæ, suddenly narrowed into the blackened beak; mesal-apical lobe of gonapophysis erect, unusually long and slender.

*Male.*—Length, about 11 to 12 millimeters; wing, 12 to 14; antenna, about 2.8 to 2.9; terminal segment of labial palpus about 0.6 to 0.7.

*Female.*—Length, about 11 to 12 millimeters; wing, 13 to 14.

Rostrum relatively long; terminal segment of labial palpus, *l*, short and broad, the length not exceeding four times the diameter or about one-half as long as the maxillary palpus, *m*, (Plate 3, fig. 31); rostrum and palpi brown. Antennæ relatively long, more than twice the maxillary palpus. Head dark brown; anterior vertex narrow.

Thorax almost uniformly dark brown; notal setæ relatively sparse but long. Halteres infuscated, extreme base of stem paler. Legs dark brown, tips of femora not or only vaguely brightened, in the paratypes the pale color barely evident; claws elongate, the cluster of basal spinules conspicuous, about five in number. Wing (Plate 1, fig. 4) strongly infuscated, stigma only slightly indicated, without a narrow marginal water mark; costal border and axillary angle slightly darker than the ground; a capilliary whitened streak in outer end of cell R; veins brown. Venation: $Sc_1$ ending m-cu at or shortly beyond the fork of M.

Abdomen brown, hypopygium, especially the dististyle, darker. Male hypopygium (Plate 3, fig. 34) with the tergite, *t*, gradually narrowed outwardly, outer margin truncate, with abundant long setæ across outer end, lower blackened scaffolding as illustrated. Basistyle, *b*, with ventromesal lobe very large but low and inconspicuous. Dististyle, *d*, with body oval, narrowed suddenly into a blackened beak, its apex obtuse; body of style with very long erect setæ, the longest exceeding the diameter of style. Gonapophysis, *g*, with mesal-apical lobe erect, unusually long and slender, straight, the extreme tip acute, curved

slightly laterad. Ædeagus relatively slender on outer half, terminating in two small lobes.

*Habitat.*—Sikkim.

Holotype, male, Chumzomoi Choka, altitude 11,800 feet, in *Rhododendron* association, July 8, 1959 (*Schmid*). Allotype, female Tangshing, altitude 14,100 feet, in *Rhododendron* association, October 6, 1959 (*Schmid*). Paratypes, males and females, with the allotype; male, Sherabtang, altitude 13,200 feet, in *Rhodordendron* association, August 27, 1959; one female, Karponang, altitude 9,900 feet, August 23, 1959 (*Schmid*).

*Limonia* (*Limonia*) *brachylabis* is quite distinct from *L.* (*L.*) *hostilis* Alexander, the only other generally similar species having the labial palpi unusually short. The distinctions between the two as shown by hypopygial structure are important, particularly the tergite, dististyle and gonapophysis.

LIMONIA (LIMONIA) STENOLABIS sp. nov. Plate 3, fig. 32.

*Male.*—Length, about 14 millimeters; wing, 12; antenna, about 2.9; terminal segment of labial palpus about 1.2.

*Female.*—Length, about 14 millimeters; wing, 16; terminal segment of labial palpus about 1.0.

Generally similar to *brachylabis*, sp.nov., differing specially in the mouthparts and in minor distinctions in the male hypopygium. Terminal segment of labial palpus, *l*, (Plate 3, fig. 32) long and slender, much shorter than in *tanyrhyncha*, longer than in *brachylabis;* palpus some 15 or more times as long as broad and slightly longer than the maxillary palpus, *m*, or somewhat less than one-half the antennæ. Femoral tips scarcely brightened. Wings with costal border and a seam along vein Cu in cell M slightly darker than the ground. Venation: Cell 1st $M_2$ relatively small, subrectangular, second section of vein $M_{1+2}$ about one-half the distal section of $M_3$. Male hypopygium with mesal-apical lobe gonapophysis a little shorter and stouter than in *brachylabis*, the acute tip longer.

*Habitat.*—Sikkim, Kumaon.

Holotype, male Chamiteng, Sikkim, altitude 9,900 feet, August 24, 1959 (*Schmid*). Allotype, female, Gopetang, Sikkim, altitude 12,500 feet, in *Rhododendron* assocation, August 26, 1959 (*Schmid*); male, Rata, Pauri Garhwal, Kumaon, altitude 11,000 feet, in *Rhododendron* association, September 14, 1958 (*Schmid*).

LIMONIA (LIMONIA) TANYRHYNCHA sp. nov. Plate 1, fig. 5; Plate 3, figs. 33, 35.

Allied to hostilis, size very large (wing of male up to 16 millimeters); general coloration of entire body dark brown; rostrum, especially the labial palpi, greatly lengthened, about equal to remainder of head and thorax; wings pale brown, variegated by large more whitened areas in many of the cells; male hypopygium with dististyle intensely blackened, the beak a slender rod, surface of body of style with abundant very long brownish yellow setæ.

*Male.*—Length, excluding rostrum, about 11 to 17 millimeters; wing, 10.5 to 16; labial palpus, about 3 to 5.2.

*Female.*—Length, excluding rostrum, about 14 to 15 millimeters; wing, 16 to 17.5; labial palpus, about 3.5 to 4.

Rostrum and especially the labial palpi (Plate 3, fig. 33) greatly lengthened, about equal to the remainder of head and the thorax combined; brownish black basally, the labial palpi, *l*, paler brownish yellow, maxillary palpi, *m*, brownish black, about one-half as long as labial palpus. Antennæ relatively long, about two-thirds the rostrum, black; flagellar segments longer than their verticils. Head above brownish black, paler posteriorly; anterior vertex narrower than the diameter of scape.

Cervical region and prothorax elongate, dark brown. Mesonotum chiefly dark brown, more yellowed on the humeral and sutural regions of præscutum and on sides of mediotergite; vestiture of præscutum sparse and small, of the scutellum abundant, long, erect. Pleura dark brown. Halteres dark, knob elongate. Legs with coxæ and trochanters medium brown; femora light brown, tips vaguely to more evidently yellowed; tibiæ dark brown, tarsi black; claws long, gently curved, with three spines, the outer elongate, the others microscopic. Wings (Plate 1, fig. 5) with the ground color pale brown, variegated by large more whitened areas in many of the cells, stigma barely differentiated; veins brown. Venation: $Sc_2$ ending about opposite two-thirds to three-fourths Rs; branches of Rs generally parallel to one another, slightly approximated at ends so cell $R_2$ at margin is very extensive, nearly four times cell $R_3$; cell 1st $M_2$ shorter than any of the veins beyond it; m-cu at fork of M.

Abdomen, including hypopygium, dark brown. Male hypopygium (Plate 3, fig. 35) with the dististyle, *d*, intensely blackened, oval, narrowed into a relatively short slender beak;

surface of body of style with abundant very long brownish yellow setæ, the longest equal to the diameter of the style. Gonapophysis, *g*, with mesal-apical lobe elongate, slightly widened outwardly.

*Habitat.*—Sikkim.

Holotype, male, Tsomgo, altitude 9,900 feet, in *Rhododendron* association, August 26, 1959 (*Schmid*). Allotype, female, Churong, altitude 12,460 feet, in *Rhododendron* association, October 8, 1959. Paratopotype, male, with type. Paratypes, male, Tangshing, altitude 12,200 feet, in *Rhododendron* association, October 5, 1959; female, Gopetang, altitude 12,200 feet, in *Rhododendron* association, October 10, 1959; male, Zomphuk, altitude 6,500 feet, October 1, 1959 (*Schmid*).

The paratype male from Zomphuk is very small, the smallest figures given under measurements, but appears to be conspecific. This outstanding fly is readily told from all other members of the *hostilis* group and all other species in the subgenus by the unusual elongation of the mouthparts.

LIMONIA (LIMONIA) ANTETERMINALSIS sp. nov. Plate 1, fig. 6; Plate 3, fig. 36.

General coloration of thorax dark brown, restrictedly patterned with obscure yellow; palpi brownish black, third segment yellowed; legs dark brown to brownish black, femora with a narrow yellow subterminal ring; wings pale brown with five darker brown costal areas, virtually all cells variegated by pale yellow marks, m-cu about one-third its length beyond fork of M; abdomen dark brown, basal segments with proximal ends narrowly yellowed; male hypopygium with the dististyle subterminal in position.

*Male.*—Length, about 10.5 to 13 millimeters; wing, 10.5 to 13; antenna, about 2.0 to 2.2.

*Female.*—Length, about 10 to 12 millimeters; wing, 11 to 13.

Rostrum dark brown; basal two segments of palpi brownish black, third yellowed, terminal segment brownish black. Antennæ relatively long; scape and pedicel yellow, proximal two flagellar segments brown, bases yellowed, outer flagellar segments brownish black, elongate, subequal to the longest verticils. Head with front and anterior vertex silvery, posterior vertex brownish black; paler brown behind; anterior vertex about one-half wider than the diameter of scape.

Pronotum dark brown. Mesonotal Præscutum and scutum dark brown, the humeral and anterior interspaces vaguely yellowed; central region of scutum and the scutellum obscure yellow; postnotum brown, broadly yellowed at the interpostnotal suture; notal vestiture black, erect, lacking on postnotum. Pleura dark brown. Halteres elongate, dark brown, base of stem and apex of knob obscure yellow. Legs with coxæ dark brown; trochanters yellow; femora dark brown to brownish black, with a single narrow yellow subterminal ring, this subequal to the darkened tip; remainder of legs brownish black to black; claws nearly straight, the outer spine at near one-third the length, basal spinules reduced. Wings (Plate 1, fig. 6) with the ground pale brown, with five darker brown costal areas, the second at origin of Rs, third at fork of Sc, fourth at stigma; numerous pale yellow areas in most cells, including about one-third to one-fourth the total area; cell C darkened at h and at outer end, with a further major area at near midlength; veins pale brown, more yellowed in the pale areas. Venation: $Sc_2$ ending a short distance before fork of Rs, much longer than the nearly transverse $Sc_1$; m-cu at near one-fourth the length of cell 1st $M_2$ or approximately one-third its own length.

Abdomen dark brown, bases of tergites two to four and stermites two to six narrowly yellowed; hypopygium yellowed outwardly. Male hypopygium (Plate 3, fig. 36) with posterior border of tergite, *t*, strongly convex, with a small apical emargination, subtended by low yellow lobes; tergal setæ abundant. Apex of basistyle, *b*, obtusely rounded. Dististyle, *d*, subterminal in position, its base oval, thence produced into a long straight yellow beak. Gonapophysis, *g*, with mesal-apical lobe pale. Ædeagus narrow.

*Habitat.*—Sikkim.

Holotype, male, Chumzomoi Choka, altitude 11,800 feet, in *Rhododendron* association, July 8, 1959 (*Schmid*). Allotype, female, Tanggu, altitude 12,800 feet, in *Rhododendron* association, June 19, 1959 (*Schmid*). Paratypes, male, Lachen, altitude 8,930 feet, May 23, 1959; males and females, Tangshing, altitude 14,100 feet, in *Rhododendron* association, October 5–6, 1959; male, Yagtang, altitude 11,650 feet, in *Rhododendron* association, June 17, 1959 (*Schmid*).

The most similar regional species is *Limonia* (*Limonia*) *kashmirica* (Edwards), described from a single female taken

at high altitudes in Kashmir. Later [Ann. Mag. Nat. Hist. (10) 1 (1928) 701–702], fig. 16 (wing) Edwards referred a male from Tibet to this species, perhaps in error. The type female has m-cu at midlength of cell 1st $M_2$ but the further male specimen has it at near one-third the cell length, not greatly different from the present fly. This latter is a much more uniformly darker fly, including the legs which are uniformly brownish black, with the exception of the abruptly yellow femoral ring.

LIMONIA (METALIMNOBIA) BRAHMA sp. nov. Plate 1, fig. 7; Plate 3, fig. 37.

Mesonotum chiefly black, præscutum with broad yellow intermediate areas, pleura brownish black; femora yellow with two black rings, the outer one narrow; wings pale yellow, conspicuously patterned with brown, including major areas in radial field, all veins behind R with series of brown dots, commonly located on both sides of the veins; Sc and Rs long; male hypopygium with rostral prolongation of ventral dististyle slender, with a long erect gently curved rod at its base.

*Male.*—Length, about 8.5 to 10 millimeters; wing, 10 to 13.

*Female.*—Length, about 8.5 to 9.5 millimeters; wing, 11.5 to 12.

Rostrum and palpi black. Antennæ relatively short, brownish black, pedicel more or less yellowed; proximal flagellar segments suboval to subcylindrical, with very short abrupt apical pedicels, more distinct in female; outer segments becoming more elongated, terminal segment long, narrowed on outer half; all flagellar segments with chiefly unilaterally distributed verticils that become single and very long on the outer seven or eight segments. Head blackened, vaguely more yellowed on the narrow anterior vertex and on occiput.

Prothorax brownish black. Mesonotal præscutum with the ground yellow, patterned with dark brown or brownish black, including a narrow central stripe that is more expanded at suture, lateral areas very broad, reaching the margins; scutum dark brown, narrowly pale silvery medially, more broadly yellowed on lateral parts of scutal lobes; scutellum brown; mediotergite brownish black, in cases slightly more yellowed on either side of midline. Pleura chiefly brownish black, extreme ventral sternopleurite yellowed. Halteres with stem yellow, knob dark brown to black. Legs with coxæ yellowed, mid pair more darkened; trochanters brownish yellow; femora yellow, with the black rings, basal one broad, outer ring very

narrow, about one-third the yellowed apex; tibiæ yellow, tips narrowly infuscated; tarsi brownish yellow, outer segments blackened; claws with about five long teeth on proximal third. Wings (Plate 1, fig. 7) with the ground pale yellow, conspicuously patterned with brown, including major areas in radial field, with narrow seams over cord and outer end of cell 1st $M_2$; all veins behind R with series of brown dots, commonly occurring on both sides of the veins, on Cu in cases only in cell M; cells of posterior half of wing with paler brown centers, these becoming darker and more conspicuous at margins of cells $M_4$, Cu and the anals; cells C and Sc almost uniformly yellow; veins pale brown, yellowed in costal region. Venation: Sc long, $Sc_1$ ending about opposite two-thirds to shortly before fork of Rs, $Sc_2$ near its tip; Rs long, angulated at origin, vaguely sinuous; cell 1st $R_2$ longer than any of the veins beyond it; m-cu shortly before fork of M.

Abdomen yellowed, more or less variegated with darker, especially on the narrow tergal borders and pleural membrane; subterminal sternites more blackened, hypopygium obscure orange. Ovipositor with cerci slender, gently curved. Male hypopygium (Plate 3, fig. 37) with the tergite, *t*, transverse, apex rounded, posterior border virtually truncate; setæ marginal, relatively short. Basistyle, *b*, with ventromesal lobe conspicuous; total area of style fully three time that of ventral dististyle. Dorsal dististyle a blackened slender gently curved sickle, very gradually narrowed into a slender spine. Ventral dististyle, *d*, bilobed, the outer lobe or body of style larger, with abundant long setæ; rostral prolongation slender, at its base on outer margin with an erect more slender gently curved rod of nearly equal length. Gonapophysis, *g*, with mesal-apical lobe slender, tip acute, narrower in the materials from Sikkim.

*Habitat.*—Sikkim, Assam.

Holotype, male, Yedang, Sikkim, altitude 10,600 feet, in *Rhododendron* association, June 5, 1959 (*Schmid*). Allotype, female, Chumzomoi Choka, Sikkim, altitude 11,800 feet, in *Rhododendron* association, July 8, 1959. Paratopotypes, two males with type. Paratypes, one female, Chachu, Sikkim, altitude 9,950 feet, in *Rhododendron* association, May 17, 1959; male, Zema, Sikkim, altitude 9,100 feet, June 14, 1959; males, Hkayam Boum, Manipur, Assam, altitude 7,500 to 8,500 feet, June 20–23, 1960 (*Schmid*); males and females, Sirhoi Kashong, Manipur, Assam, altitude 6,000 feet, June 6–8, 1960 (*Schmid*).

This attractive fly is readily told from all other described regional allies by the abundantly dotted and spotted wings and the pattern of the femora. *Limonia* (*Metalimnobia*) *hedone* Alexander has a few brown dots along vein Cu in cell M but these are lacking on the other veins. *L.* (*M.*) *jactator* Alexander and *L.* (*M.*) *biannulata* (Brunetti), which Edwards believed to be virtually identical with the Indonesian *L.* (*M.*) *annulifemur* (de Meijere), are quite different flies.

LIMONIA (METALIMNOBIA) XANTHOPTEROIDES ADONIS subsp. nov. Plate 1, fig. 8; Plate 3, fig. 38.

Size medium (wing of male 11 millimeters); mesothorax yellow, præscutum with four brownish black stripes; antennæ with scape and pedicel light yellow, flagellum brownish black; front and anterior vertex yellow, posterior vertex black; legs black, bases of fore femora yellowed, all femora with a narrow yellow subterminal ring; wings yellow, with a pale brown inconspicuous pattern that is virtually restricted to the outer three-fourths; male hypopygium with the body of ventral dististyle very small, rostrum elongated; mesal-apical lobe of gonapophysis very slender, at apex with a brush of long setæ.

*Male.*—Length, about 10 millimeters; wing, 11; antenna, about 2.2.

*Female.*—Length, about 9.5 millimeters; wing, 12.5.

Rostrum brownish black; palpi black. Antennæ with scape and pedicel light yellow, flagellum brownish black; basal flagellar segments oval, outer ones progressively more elongated; verticils long. Front and anterior vertex clear light yellow, posterior vertex abruptly black, genæ paler.

Pronotum brownish black medially, sides broadly yellow. Mesonotal præscutum yellow with four clearly defined brownish black stripes, the intermediate pair barely divided by a ground line; posterior sclerites of notum yellow, scutal lobes patterned with brownish black. Pleura yellow, dorsopleural membrane slightly darker; a very small brown spot before wing root. Halteres brownish yellow, base of stem clearer yellow, apex of knob infuscated. Legs with coxæ and trochanters yellow; femora blackened, with a narrow yellow subterminal ring; fore femora with about the proximal third yellowed, the other femora with this barely indicated; remainder of legs blackened; claws with about five teeth, the outermost largest. Wings (Plate 1, fig. 8) with the ground yellow, prearcular and costal fields clear saturated yellow; an

inconspicuous pale brown pattern, including the large stigma, an area at origin of Rs, anterior cord and outer end of cell 1st $M_2$; further paler brown washes before wing tip and in outer ends of anal cells, outer ends of cells $R_3$ and $R_5$ slightly yellowed; veins brown, more yellowed in the brightened fields. Venation: Sc long, $Sc_1$ ending just beyond the fork of Rs, $Sc_2$ near its tip; cell 1st $M_2$ relatively small, shorter than any of the veins beyond it; m-cu shortly before fork of M.

Abdominal tergites fulvous brown, sternites more yellowed, subterminal segments blackened to form a narrow ring; genitalia of both sexes yellow. Ovipositor with cerci short, very slender. Male hypopygium (Plate 3, fig. 38) with the posterior border of tergite, *t*, nearly truncate, the lobes scarcely developed, each provided with about 20 strong setæ; proctigeral extension pale. Basistyle, *b*, elongate, ventromesal lobe rounded. Dorsal dististyle, *d*, a powerful flattened blade, the outer third narrowed into a slender decurved spine, basal half of blade with about 10 strong setæ; inner dististyle with body very small, with very long setæ; rostral prolongation narrow, subequal in length to the outer style, outer half a little dilated. Gonapophysis, *g*, with mesal-apical lobe very slender, apex with a brush of long pale setæ.

*Habitat.*—Sikkim.

Holotype, male, Yedang, altitude 10,600 feet, in *Rhododendron* association, June 9, 1959 (*Schmid*). Allotopotype, female, pinned with type.

I am placing the present fly as a race of *Limonia* (*Metalimnobia*) *xanthopteroides* (Riedel), described from Formosa, with slightly differentiated other forms in western China. The species is quite distinct from the Palæarctic *L.* (*M.*) *bifasciata* (Schrank).

**LIMONIA (LIBNOTES) PRAMATHA sp. nov.** Plate 1, fig. 9; Plate 4, fig. 39.

General coloration of thorax almost uniformly light fulvous, unpatterned; rostrum yellow; legs pale yellowish brown; wings pale yellow, prearcular and costal borders clearer yellow, disk with a pale brown pattern; m only a little longer than basal section of $M_3$; male hypopygium with two pale rostral spines; mesal-apical lobe of gonapophysis pale, apex obtuse.

*Male.*—Length, about 8 millimeters; wing, 9; antenna, about 1.5.

Rostrum clear light yellow, subequal in length to the antennal scape; labial palpi yellow, more than one-half remainder

of rostrum; maxillary palpi with basal segment brownish yellow, outer segments black. Antennæ brownish black; basal flagellar segments short-oval, the outer ones more elongate; longest verticils exceeding the segments, unilaterally arranged. Front silvery; eyes nearly contiguous, the anterior vertex reduced to a capillary gray strip; posterior vertex obscure yellow.

Pronotum obscure yellow, scutellum clearer yellow. Mesonotum almost uniformly light fulvous, unpatterned, lateral præscutal borders narrowly more whitened. Pleura yellow, with a pale brown suffusion that includes the propleura and anepisternum. Halteres with stem yellow, knob dark brown. Legs with coxæ and trochanters yellow, free coxæ infuscated; remainder of legs uniformly pale yellowish brown, the outer tarsal segments dark brown. Wings (Plate 1, fig. 9) pale yellow, prearcular region and costal border clearer more saturated yellow; a pale brown pattern that is restricted to the veins, including a small cloud at origin of Rs, with more extensive areas over cord, outer end of cell 1st $M_2$, fork of Sc, and over $R_2$ and adjoining veins; outer third of vein 2nd A clouded with a further vague darkening at near basal fourth of cell Sc; veins clear light yellow, pale brown in the patterned areas. Venation: Sc long, $Sc_1$ ending beyond level of m-cu, $Sc_2$ close to its tip; Rs nearly straight, basal section of $R_{4+5}$ short, less than m-cu; $R_2$ and free tip of $Sc_2$ in transverse alignment; vein $R_3$ very slightly decurved at tip, $R_{4+5}$ virtually straight; cell 1st $M_2$ narrow, slightly widened outwardly, subequal in length to distal section of $M_3$, m only a trifle longer than the straight basal section of $M_3$; m-cu shortly before midlength of $M_{3+4}$; vein 2nd A convergent, gently arcuated to the margin.

Abdomen yellow, scarcely patterned, hypopygium yellow. Male hypopygium (Plate 4, fig. 39) with the tergite, *t*, transverse, posterior border very gently emarginate, borders narrowly thickened, provided with few moderately long delicate setæ. Basistyle, *b*, with ventromesal lobe oval, with abundant long pale brown setæ. Dorsal dististyle a long sinuous rod, its tip slightly decurved. Ventral dististyle, *d*, small, its area about two-thirds that of the basistyle; rostral prolongation a narrow yellow blade; rostral spines two, basal, elongate, pale, placed very close together; axillary lobule long, pale, tipped with the two powerful setæ. Gonapophysis, *g*, pale, body very small, mesal-apical lobe a flattened straight blade,

tip obtuse. Ædeagus stout, terminating in two large oval lobes.

*Habitat.*—Assam.

Holotype, male, Sirhoi Kashong, Manipur, altitude 6,000 feet, June 7, 1960 (*Schmid*).

This attractive fly is told from other regional species of the subgenus by the uniform fulvous coloration of the mesonotum, coloration of the legs and wings, venation, and details of the male hypopygium, particularly the ventral dististyle. The general structure of the hypopygium is much as in *Limonia* (*Libnotes*) *punctithorax* (Brunetti) and other allied species, but the details, as the number of rostral spines, are quite distinct.

**LIMONIA (LIBNOTES) SHARVA** *sp. nov.* **Plate 1, fig. 10; Plate 4, fig 40.**

Size medium (wing of male 9 millimeters); mesonotum almost uniformly yellowish brown, ventral pleura clearer yellow; femora yellow, with a very conspicuous black subterminal ring; wings brownish yellow, unpatterned except for the small pale brown stigma, Sc long; male hypopygium with tergite long, rostral prolongation of ventral dististyle with three spines that are conspicuously narrowed into hairlike points.

*Male.*—Length, about 8 millimeters; wing, 9; antenna, about 1.8.

Rostrum brownish black; palpi black. Antennæ brownish black, pedicel more yellowed; flagellar segments oval, longer than the verticils; terminal segment about one-third longer than the penultimate, strongly narrowed on outer third. Head dark grayish brown, with very conspicuous black setæ; eyes contiguous above, obliterating the anterior vertex.

Pronotum medium brown. Mesonotum almost uniformly yellowish brown, Præscutum with very faintly differentiated nearly concolorous stripes; præscutum and scutum with sparse erect black setæ. Pleura brownish yellow above, clearer yellow on sternopleurite, meron and metapleura. Halteres short, stem obscure yellow, knob more infuscated. Legs with coxæ and trochanters yellow, fore coxæ slightly darker; femora yellow, with a very conspicuous black subterminal ring, on fore legs subequal to the yellow tip, on middle and hind femora broader, nearly twice the tip; remainder of legs brownish black, bases of tibiæ narrowly more yellowed; claws with two major spines, the outer one appressed, its tip acute, basal spine erect, tip obtuse. Wings (Plate 1, fig. 10) brownish yellow, costal border clear yellow; no dark pattern excepting

the small obliquely oval pale brown stigma; veins brown, those in costal field more yellowed. Venation: $Sc_1$ ending about opposite fork of Rs, $Sc_2$ at its tip; cell 1st $M_2$ shorter than distal section of $M_3$; m-cu nearly one-half its length beyond fork of M.

Abdomen brown, hypopygium yellowed. Male hypopygium (Plate 4, fig. 40) with the tergite, *t*, unusually long, the length only a little less than the breadth across the base, gradually narrowed outwardly; posterior border with a shallow emargination, lobes low, oval, with relatively few long setæ. Basistyle, *b*, with ventromesal lobe oval, with long setæ. Dorsal dististyle a gently curved yellow rod, gradually narrowed into a long spine. Ventral dististyle, *d*, about three-fourths the area of basistyle; rostal prolongation slender, with a single long seta on outer margin at near midlength; spines three, placed close together in a row, stout on basal half, thence narrowed into a hairlike point; a conspicuous tubercle on mesal face of style near base, tipped with three or more strong setæ. Gonapopysis, *g*, with mesal-apical lobe pale, broad at base, narrowed into a subacute point. Ædeagus terminating in two small lobes.

*Habitat.*—Assam.

Holotype, male, Hkayam Boum, Manipur, altitude 8,500 feet, June 21, 1960 (*Schmid*).

*Limonia* (*Libnotes*) *sharva* is quite distinct from other regional species that have unpatterned wings and a subterminal darkened femoral ring. The hypopygial structure shows it to be closer to *L.* (*L.*) *punctithorax* (Brunetti) and some allied species rather than to *L.* (*L.*) *indica* (Brunetti) and others. These latter flies will probably be placed in the subgenus *Goniodineura* van der Wulp.

LIMONIA (LIBNOTES) TARTARUS sp. nov. Plate 1, fig. 11.

Size large (wing of male 17.5 millimeters); general coloration of thorax yellow, conspicuously patterned with brownish black, including two pleural stripes; knobs of halteres blackened; legs beyond the trochanters black; tip of mid femur narrowly pale; wings light yellow, cell C extensively dark brown; veins with a series of paler brown spots; m at near three-fourths the length of cell 1st $M_2$; abdomen chiefly orange, narrowly lined laterally with black.

*Male.*—Length, about 14 millimeters; wing, 17.5.

Rostrum brown, palpi black. Antennæ with scape and pedicel black, flagellar segments weakly bicolored, bases slightly infuscated, tips paling to obscure yellow, the ninth and suc-

ceeding segments more uniformly darkened; flagellar segments oval, subequal to the longest verticil. Head brown in front, paling to obscure yellow on occipital region; anterior vertex very narrow to virtually eliminated by the eyes, tubercle of anterior vertex slightly developed.

Pronotum yellow. Mesonotal præscutum yellow, with a broad central brownish black stripe on posterior half, widened behind, divided at suture into narrower lines that extend parallel to one another to the abdomen, involving the inner parts of the scutal lobes, lateral margines of scutellum and broad blackenings on sides of postnotal mediotergite and dorsal pleurotergite, the latter confluent with a black dorsopleural stripe extending from the cervical region backward; remainder of pleura greenish yellow, with a further narrow ventral brownish black stripe extending from fore coxæ across the dorsal sternopleurite, above the posterior coxæ to abdomen, interrupted above the mid-coxæ. Halteres yellow, knob brownish black. Legs with coxæ greenish yellow, fore pair patterned with brownish black, as described; trochanters greenish yellow; remainder of legs black, the tips of middle femora narrowly greenish white, last tarsal segment of fore leg obscure yellow; claws with outer spine more than one-third as long as the apex, more basal spinules crowded. Wings (Plate 1, fig. 11) with the ground light yellow, conspicuously patterned with dark brown, including basal half of cell C; stigma dark brown; cord and outer end of vein 2nd A conspicuously seamed with dark brown; all veins excepting 2nd A with smaller paler brown spots, more extensive at end of vein $M_{1+2}$; veins yellow, dark in the patterned areas, including the entire cord. Venation: Free tip of $Sc_2$ lying far beyond $R_2$, vein $Sc_2+R_{1+2}$ being about three times $Sc_2$ alone; anterior cord strongly oblique; all outer veins strongly decurved, $R_{4+5}$ ending beyond the wing apex; m relatively short, less than three times the basal section of $M_3$, at near three-fourths the length of cell 1st $M_2$; m-cu oblique, about its own length beyond fork of M.

Abdominal tergites orange, basal seternites more yellowed; first tergite and extreme lateral borders of succeeding segments blackened; lateral margins of sternites with a narrow black area, disconnected on three proximal segments, on four to seven continuous and more extensive; hypopygium greenish yellow.

*Habitat.*—Assam.

Holotype, male, Rumkheng, Khasi-Jaintia, altitude 5,500 feet, March 26, 1960 (*Schmid*).

*Limonia* (*Libnotes*) *tartarus* is entirely distinct from *L.* (*L.*) *sicca* Alexander, the only other regional species that has at least the fore legs black and without a supernumerary crossvein in cell $R_3$. Species having the latter character are now placed by me in the subgenus *Laosa* Edwards, based on this feature, and includes *Limonia* (*Laosa*) *dolonigra* Alexander, which likewise has the legs similarly brownish black. *L.* (*L.*) *sicca* has the wing pattern and venation of the outer radial field quite different from the present fly.

**LIMONIA ASPROPODA sp. nov.** Plate 1, fig. 12; Plate 4, figs. 41, 42.

Size medium (wing about 5.5 millimeters); mesonotal præscutum light brown with a narrow darker central line; antennæ of male elongate, nearly two-thirds the wing; flagellar segments elongate cylindrical, with abundant setæ; anterior vertex broad, brilliant silvery; legs brownish black, outer ends of all tarsi snowy white; wings strongly blackened, Sc long; abdomen dark brown, posterior borders of segments broadly gray; male hypopygium with apex of rostral prolongation of ventral dististyle pendant, with two long straight rostral spines.

*Male.*—Length, about 5 to 6 millimeters; wing, 5.3 to 5.5; antenna, about 3.3 to 3.5.

*Female.*—Length, about 5.5 millimeters; wing, 5.6.

Rostrum and palpi small, brownish black. Antennæ of male elongate, black throughout; flagellar segments elongate-cylindrical, with very abundant erect black verticils and shorter more delicate setæ, the vestiture of outer segments somewhat longer. Anterior vertex broad, brilliant silvery; posterior vertex brownish black.

Pronotum dark brown. Mesonotal præscutum and scutum chiefly light brown, the former with a narrow darker brown central stripe; scutellum darker brown, narrowly more yellowed posteriorly; postnotum obscure yellow. Pleura yellow, propleura and dorsopleural region darker. Halteres blackened. Legs with fore coxæ pale brown, remaining coxæ and all trochanters yellow; femora and tibiæ brownish black, basitarsi the same, the tips and remainder of all tarsi snowy white. Wings (Plate 1, fig. 12) strongly blackened, the oval stigma and costal border still darker; veins dark brown. Longitudinal veins beyond general level of origin of Rs with strong macrotrichia. Venation: Sc long, $Sc_1$ ending about opposite two-thirds to three-fourths Rs, $Sc_2$ near its tip; free tip of

$Sc_2$ and $R_2$ in transverse alignment or the latter slightly more basal; m-cu at or before fork of M.

Abdomen dark brown, the posterior borders of segments pale gray to silvery, terminal segments black. Ovipositor with valves pale yellow, very slender. Male hypopygium (Plate 4, figs. 41, 42) with posterior border of tergite, *t*, convex, scarcely emarginate at apex, with long setæ on outer fourth. Basistyle, *b*, with ventromesal lobe large. Dorsal dististyle narrowed on about the outer fifth, the long tip acute. Ventral dististyle, *d*, of moderate size, its area somewhat greater than that of the basistyle; rostrum slender, the outer half pendant, before the bend with two closely approximated spines. Gonapophysis, *g*, with mesal-apical lobe slender. Ædeagus very narrow, especially on outer half.

*Habitat.*—Assam, Sikkim.

Holotype, male, Mawshun, Khasi-Jaintia, Assam, altitude 2,000 feet, January 24, 1960 (*Schmid*). Allotype, female, Laittyngkot, Khasi-Jaintia, altitude 4,800 feet, March 17, 1960. Paratypes, female, with the allotype, March 17, 1960; male, Lingdok, Sikkim, altitude 4,600 feet, May 7, 1959 (*Schmid*).

In the coloration of the body and wings *Limonia aspropoda* differs from *L. niveipes* (Brunetti), the only other regional species known to have the tarsi of all legs snowy white. The broad silvery anterior vertex suggests species of the subgenus *Melanolimonia* subgen. nov., but the reference to that group is impossible. The smaller and otherwise different *L. gentilis* Alexander likewise may be related to the present fly since it agrees in antennal structure and in general features of the hypopygium. The coloration of the legs in *gentilis* still is unknown but it very probably will be found to have white tarsi, as in this species. The Sikkim paratype has the mesal-apical lobe of the gonapophysis (Plate 4, fig. 42) shorter and the ædeagus narrower than in the type but appears to be conspecific.

LIMONIA BHIMA sp. nov. Plate 1, fig. 13; Plate 4, fig. 43.

Size large (wing of male 11 millimeters); mesonotum reddish brown, præscutum with a broad darker brown central stripe; femora yellow, tips very narrowly infuscated; wings very pale brown, restrictedly patterned with dark brown, with two whitened areas at ends of cells Cu and 1st A; Sc long, ending about opposite three-fourths Rs; male hypopygium

with the tergal lobes long and slender, basistyle with ventromesal lobe very large, with abundant long yellow setæ; ventral dististyle with rostral spines black, placed close together; gonapophysis with mesal-apical lobe very long and slender.

*Male.*—Length, about 9.5 millimeters; wing, 11; antenna, about 1.5.

Rostrum dark brown, palpi black. Antennæ black, pedicel brownish black; basal flagellar segments subglobular, gradually passing into oval, outer segments slightly exceeding their verticils. Head dark gray; anterior vertex slightly narrowed than the diameter of scape.

Pronotum reddish brown. Mesonotal præscutum reddish brown with a broad darker brown central stripe that narrows behind, not reaching the suture; scutum yellow, lobes suffused with brown; posterior sclerites of notum silvery yellow pollinose. Pleura light brownish gray, propleura, anepisternum and dorsal sternopleurite slightly infuscated. Halteres pale brown, base of stem yellowed, knob expanded, darkened apically, stem fringed with unusually long setæ. Legs with coxæ yellow, fore pair darkened; trochanters yellow; femora yellow, tips very narrowly and inconspicuously infuscated; tibiæ and proximal tarsal segments yellow, outer segments blackened. Wings (Plate 1, fig. 13) very pale brown, restrictedly patterned with dark brown, including small clouds at origin of Rs, $Sc_2$, stigma, cord and outer end of cell 1st $M_2$; conspicuous marginal areas in cells Cu and 1st A, adjoining the veins behind; veins brownish yellow, darker in the clouded areas, Sc clear yellow. Venation: Sc long, $Sc_1$ ending about opposite three-fourths Rs, $Sc_2$ close to its tip; basal section of $R_{4+5}$ strongly arcuated at origin; cell 1st $M_2$ nearly equal in length to distal section of $M_{1+2}$; m-cu just before fork of M; vein 2nd A oblique at apex.

Abdomen cinnamon brown, vaguely clouded with darker, hypopygium more yellowed. Male hypopygium (Plate 4, fig. 43) with the tergite, *t*, transverse, posterior border produced into two unusually long and slender lobes that are separated by a deep U-shaped notch, the entire outer margin, including lobes, more sclerotized, with long setæ, these becoming more concentrated and numerous at apices of lobes. Basistyle, *b*, with ventromesal lobe very large, nearly equal in area to body of style, ventral surface and apex with abundant long yellow setæ. Dorsal dististyle a strong sickle, gradually narrowed

into a long spine. Ventral dististyle, *d*, large and fleshy, its area subequal to the total extent of basistyle; rostral prolongation triangular, almost glabrous, lacking the usual apical setæ; spines two, blackened, placed close together at summit of a dusky tubercle. Gonapophysis, *g*, with mesal-apical lobe very long and slender, gently curved. Ædeagus moderately stout, glabrous, apex bilobed.

*Habitat.*—Sikkim.

Holotype, male, Chumzomoi Choka, altitude 11,800 feet, in *Rhododendron* association, July 8, 1959 (*Schmid*).

*Limonia bhima* is entirely different from other regional members of the genus having a so-called '*Dicranomyia*' type of hypopygium, in the elongate vein Sc. Peculiar features of the hypopygium include the slender tergal lobes and the unusually large ventromesal lobe of the basistyle.

**LIMONIA INDEFESSA sp. nov.** **Plate 1, fig. 14; Plate 4, fig. 44.**

General coloration of thorax light brown, pleura darker; head behind dark brown, anterior vertex broad, clear light silvery; antennæ moderately long, about one-fourth the wing; legs brown; wings strongly tinged with brown, stigma darker, Sc long; male hypopygium with posterior border of tergite convex; basistyle with ventromesal lobe unequally bilobulate; rostrum of ventral dististyle with two long gently curved spines.

*Male.*—Length, about 5 millimeters; wing, 6; antenna, about 1.5.

Rostrum obscure yellow, palpi black. Antennæ dark brown, relatively long; flagellar segments oval to subcylindrical, much exceeding the verticils, with short abrupt apical pedicels; terminal segment slender, about one-third longer than the penultimate. Anterior vertex broad, clear light silvery, very conspicuous; posterior vertex dark brown.

Pronotum small and compact, dark brown. Mesonotum chiefly light brown, scutal lobes darker brown, central region of scutum, scutellum and postnotum more yellowed. Pleura dorsally dark brown, ventral sclerites more yellowed. Halteres with stem infuscated, knob darker. Legs with coxæ and trochanters obscure yellow, fore coxæ slightly darker; remainder of legs brown, tarsi very slightly paler. Wings (Plate 1, fig. 14) strongly tinged with brown, prearcular field paler; stigma oval, darker brown. Macrotrichia on longitudinal veins beyond general level of origin of Rs, including outer two-

thirds of Sc, lacking on anals and most of basal section of $Cu_1$. Venation: Sc long, $Sc_1$ ending opposite three-fifths Rs, $Sc_2$ near its tip; free tip of $Sc_2$ and $R_2$ pale, in transverse alignment, $R_{1+2}$ extended beyond as a strong setiferous spur; m-cu before fork of M; cell 2nd A long.

Abdomen dark brown. Male hypopygium (Plate 4, fig. 44) with the tergite, *t*, transverse, without sclerotized margins; posterior border convex, central area with nine or ten long setæ, with two or three smaller lateral setæ. Basistyle, *b*, subequal in area to the ventral dististyle, the large ventromesal lobe divided into two unequal lobules, both tipped with long setæ; more numerous shorter setæ on mesal face of style. Dorsal dististyle a long slender rod, outer end gently curved into a long spine. Ventral dististyle, *d*, fleshy, prolongation relatively small, on outer margin with two long pale slightly unequal gently curved spines. Gonapophysis, *g*, with mesal-apical lobe a slender curved darkened spine. Ædeagus slender, glabrous.

*Habitat.*—Assam.

Holotype, male, Pynter, Khasi-Jaintia, altitude, 1,700 feet, January 20, 1960 (*Schmid*).

*Limonia indefessa* is still another species that has the venation generally as in the subgenus but with the male hypopygium more as in *Dicranomyia*. I know of no close relative. The broad silvery anterior vertex is much as in the various species of the subgenus *Melanolimonia* but there seems to be no close relationship between the two groups.

LIMONIA LUTEIPOSTICA sp. nov. Plate 1, fig. 15; Plate 4, fig. 45.

General coloration of notum brown, præscutal margins broadly yellow; legs light brown, second tarsal segment of posterior legs yellowish white; wings light brown, very restrictedly patterned with darker brown; Sc long, $Sc_1$ ending about opposite two-thirds Rs, $Sc_2$ near its tip; abdominal tergites medium brown, sternites light yellow; male hypopygium with the ventral dististyle elongate-oval, narrowed outwardly into a sclerotized point, rostral spines on face of style at near two-thirds the length.

*Male.*—Length, about 5.5 millimeters; wing, 6.5; antenna, about 1.

Rostrum very short, palpi black, moderately long, outer two segments oval, subequal. Antennæ with scape brown, remainder black; relatively short, basal flagellar segments

short-oval, outer ones more elongate, the lower faces of segments short-oval, outer ones more elongate, the lower faces of segments not produced, as in *luteitarsis;* terminal segment about one-third longer than the penultimate. Front yellow, remainder of head light brown, restrictedly patterned with darker brown, anterior vertex light gray pruinose, very broad, about three times the diameter of scape.

Pronotal scutum brownish yellow, sides of scutellum darker brown, anterior pretergites very pale yellow. Disk of præscutum almost uniformly dark chestnut brown, lateral borders broadly yellow, remainder of notum chestnut brown; setæ of præscutum and scutum sparse but long and conspicuous, scutellum and postnotum glabrous. Pleura with a medium brown dorsal stripe, ventral sclerites light yellow, ventral sternopleurite vaguely darkened. Halteres brownish black. Legs with coxæ and trochanters light yellow, fore coxæ weakly darkened at bases; remainder of fore and middle legs light brown, posterior legs light brown, the second tarsal segment yellowish white, third and fourth very pale brown, terminal segment darker. Wings (Plate 1, fig. 15) tinged with very light brown, restrictedly patterned with darker brown, including narrow vague seams at origin of Rs, fork of Sc, cord and outer end of cell 1st $M_2$; stigma short-oval, slightly darker brown; veins very pale brown. Venation: Sc long, $Sc_1$ ending about opposite two-thirds Rs, $Sc_2$ near its tip; free tip of $Sc_2$ and $R_2$ in trasverse $_{1+2}$ alignment; cell 1st $M_2$ nearly as long as distal section of $M_{1+2}$; m-cu about one-fourth its length before fork of M.

Abdominal tergites medium brown, sternites light yellow; hypopygial dististyles paler. Male hypopygium (Plate 4, fig. 45) with tergite, *t*, transverse, posterior border very shallowly emarginate, all borders thickened, especially the posterior one which bears relatively few but long setæ. Basistyle, *b*, with ventromesal lobe unmodified. Dorsal dististyle a slender pale rod, nearly straight, the blackened tip acute, gently decurved. Ventral dististyle, *d*, long and narrow, its area less than one-half that of the basistyle; body oval, narrowed outwardly, terminating in a sclerotized point, with numerous strong setæ near apex; rostral spines two, placed close together far back on face of style at near two-thirds the length; spines long and slender but inconspicuous. Gonapophysis, *g*, with mesal-apical lobe stout, inner apical angle slightly produced, blackened, the

adjoining margin inconspicuously roughened or erose. Ædeagus, *a*, broad, glabrous, terminating in two truncated lobes.

*Habitat.*—Sikkim.

Holotype, male, Yedang, altitude 10,600 feet, in *Rhododendron* association, June 9, 1959 (*Schmid*).

Superficially, the most similar regional species is *Limonia luteitarsis* sp. nov., which differs in the structure of the antennæ and palpi, coloration of the thorax, wings and legs, and especially in the very different male hypopygium.

LIMONIA LUTEITARSIS sp. nov. Plate 1, fig. 16; Plate 4, fig. 46.

General coloration of mesonotal præscutum polished chestnut brown, yellow on sides; rostrum, including the palpi, greatly reduced; antennæ with proximal flagellar segments transverse-subglobular, their lower faces rounded, slightly produced; legs yellow; wings fulvous brown, unpatterened except for the pale brown stigma; Sc long, inner end of cell 1st $M_2$ arcuated; male hypopygium with rostral prolongation elongate, the two spines very long and slender, basal in position, directed cephalad.

*Male.*—Length, about 6.5 millimeters; wing, 7.2; antenna, about 1.3.

Mouthparts greatly reduced, maxillary palpi apparently a single segment. Antennæ short, brownish black, extreme base of scape obscure yellow; basal flagellar segments transversely-subglobular, the lower face slightly produced, rounded; outer segments oval, the terminal one about one-third longer than the penultimate, narrowed outwardly; verticils shorter than the anterior vertex yellow, the remainder polished chestnut; anterior vertex broad, nearly three times the diameter of scape.

Pronotum obscure yellow. Mesonotal præscutum with disk polished chestnut brown, lateral borders broadly more yellowed; scutal lobes polished brown, median region and scutellum more yellowed; postnotum light brown. Pleura and pleurotergite polished yellow. Halteres light brown, knob darker brown. Legs with coxæ and trochanters yellow; remainder of legs obscure yellow to brownish yellow, second tarsal segment of all legs conspicuously yellowish white, including the vestiture, on posterior legs more extensive, including outer end of segment one and basal half of segment three; remaining tarsal segments brown, the last darker; claws long, gently curved, with a long straight basal spine. Wings (Plate 1, fig. 16) strongly fulvous brown, stigma slightly darker, pale brown;

veins very pale brown. Trichia of anal veins virtually lacking, reduced to one or two near tips. Venation: Sc long, $Sc_1$ ending about opposite four-fifths Rs, $Sc_2$ not far removed; free tip of $Sc_2$ slightly basad of $R_2$; cell 1st $M_2$ elongate, subequal to distal section of $M_3$; inner end arcuated; m-cu at fork of M.

Abdomen dark brown, hypopygium a trifle more yellowish brown. Male hypopygium (Pate 4, fig. 46) with the posterior border of tergite, *t*, truncate or very shallowly emarginate. Basistyle, *b*, with ventromesal lobe large, obtuse. Dorsal dististyle a delicate nearly straight yellow rod. Ventral dististyle, *d*, small, its total area about one-half that of the basistyle; body of style oval, with long setæ; rostral prolongation a long gently curved glabrous yellow blade; rostral spines at extreme base of prolongation, long and very slender, appearing almost as long curved setæ, placed close togteher, directed cephalad or ventrad instead of outwardly, as usual in the genus. Gonapophysis, *g*, yellow, narrowed gradually to the obtusely rounded apex, the lateral border very inconspicuously produced. Ædeagus glabrous, apex bilobed.

*Habitat.*—Kumaon.

Holotype, male, Kanol, Pauri Garhwal, altitude 8,530 feet, August 19, 1958 (*Schmid*).

*Limonia luteitarsis* is still another of the many species that have the venation generally as in *Limonia* while having the male hypopygium quite as in *Dicranomyia*, as discussed in the introduction. The closest ally seems to be *Limonia citrofocalis* (Edwards), of Borneo, which has the antennal structure and mouthparts approximately as in the present fly, differing in all other features of coloration and venation.

**LIMONIA PERNODOSA** sp. nov. Plate 1, fig. 17; Plate 5, fig. 47.

Size small (wing of male up to 5 millimeters); antennæ black throughout, in male the flagellar segments very conspicuously nodose, the abrupt apical pedicels longer than the basal enlargements; mesonotal præscutum brownish yellow with a broad central dark brown stripe; femora brown, extreme tips whitish; wings weakly tinged with brown, stigma pale brown, subcircular; m-cu at or beyond midlength of $M_{3+4}$; male hypopygium with ventral dististyle conspicuously trilobed, the intermediate arm with a comb of about ten flattened peglike spines.

*Male.*—Length, about 4.5 to 5.5 millimeters; wing, 4.5 to 5; antenna, about 2.4 to 2.6.

*Female.*—Length, about 5.5 millimeters; wing, 5.5.

Rostrum black, relatively long and slender, only a little shorter than remainder of head, palpi, black. Antennæ relatively long, black throughout, scape more pruinose; flagellar segments of male nodose, the basal swellings oval, abruptly narrowed into slender apical pedicels that slightly exceed the bases, terminal segment elongate, simple; basal swellings each with a single very elongate black verticil and more abundant delicate pale setæ that are about one-half as long. Head brownish black, sparsely pruinose; anterior vertex light gray, very narrow.

Pronotum brown. Mesonotal præscutum brownish yellow, with a broad central dark brown stripe and a small marginal brown cloud behind the humeri; posterior sclerites of notum brownish yellow, scutal lobes and scutellum brown. Pleura pale brown, dorsal sternopleurite and the posterior pleurites yellowed. Halteres with stem yellow, knob large, brownish black. Legs with coxæ and trochanters yellow; fenora brown, base vaguely paler, extreme tip whitened; tibiæ and tarsi light brown; claws small, denticles basal, inconspicuous. Wings (Plate 1, fig. 17) weakly tinged with brown; stigma pale brown, subcircular; veins brown, with long conspicuous black macrotrichia on virtually all longitudinal veins, lacking on base of M and 1st A. Venation: Sc long, $Sc_1$ opposite fork of Rs, $Sc_2$ near tip; free tip of $Sc_2$ about its own length before $R_2$; cell 1st $M_2$ rectangular, a little shorter than vein $M_4$; m-cu at midlength to about two thirds $M_{3+4}$.

Abdominal tergites brownish black, basal and ninth sternite more yellowed. Male hypopygium (Plate 5, fig. 47) with the tergite, *t*, narrowed outwardly, posterior border with a V-shaped emargination, lobes rounded, each with about eight long setæ. Basistyle, *b*, elongate; ventromesal lobe small, oval, with long setæ. Dorsal dististyle a stout darkened blade, narrowed to a long acute point. Ventral dististyle, *d*, relatively small, its area about two-thirds that of the basistyle, conspicuously trilobed, the lower lobe terminating in a strong point; intermediate arm smaller, its margin with a comb of about ten slattened peglike spines. Gonapophysis, *g* blackened, smooth. Ædeagus long and straight.

*Habitat.*—Assam.

Holotype, male, Ronghongkung, Khasi-Jaintia, altitude 200 feet, December 9, 1959 (*Schmid*). Allotopotype, female, pinned with type. Paratopotypes, 2 males.

The very strongly nodose antennæ of the present fly readily distinguish it from all other regional species. *Limonia monilis* Alexander and *L. multinodulosa* Alexander of the Philippines have somewhat similar antennæ but differ conspicuously in the venation and hypopygial structure. The distal position of m-cu in the present fly suggests the condition found in the subgenus *Libnotes* Westwood.

LIMONIA USHAS sp. nov. Plate 1, fig. 18; Plate 5, fig. 48.

Mouthparts unusually long; thorax obscure yellow, præscutum with a central brown stripe, pleura yellowed, with a broad brownish black longitudinal stripe; wings brownish yellow, patterned with brown, including cell C; male hypopygium with tergite extended directly into the proctigeral region, without a defined posterior border; rostral spines short; mesal-apical lobe gonapophysis darkened, elongate.

*Male.*—Length, about 5.8 millimeters; wing, 6.8; antenna, about 1.2.

*Female.*—Length, about 6 millimeters; wing, 6.8.

Mouthparts brown, elongate, rostrum and labial palpi together subequal in length to remainder of head; labial palpi about four-fifths as long as the black maxillary palpi. Antennæ black, outer flagellar segments paler; basal flagellar segments short-oval, outer segments longer; terminal segment about one-half longer than the penultimate. Head blackened, sparsely pruinose; anterior vertex narrow, about one-third the diameter of scape.

Pronotum dark brown. Mesonotal præscutum obscure yellow with a broad central brown stripe, the lateral borders of latter still darker; scutal lobes brown, margined internally by darker, median region and base of scutellum obscure yellow, the latter darkened behind; mediotergite light brown, obscure yellow posteriorly. Pleura and pleurotergite yellowed, with a broad brownish black longitudinal stripe extending from cervical region to abdomen, passing beneath the halteres. Halteres short, stem yellow, knob light brown. Legs with coxæ yellow, the fore pair with a narrow brown line that is continued across the sternopleurite; trochanters yellow; femora yellowed basally, tips dark brown, broadly so on fore legs, more narrowly on the remainder; tibiæ obscure yellow; tarsi brown, darker outwardly. Wings (Plate 1, fig. 18) brownish yellow, con-

spicuously patterned with brown, including cell C beyond h; darkened seams at origin of Rs, cord and outer end of cell 1st $M_2$; a restricted seam on vein 2nd A; very weak clouds in centers of outer cells and basal half of R; prearcular field light yellow; veins yellowish brown, darker brown in the patterned fields, Cu more yellowed. Venation: Sc long, $Sc_1$ ending about opposite three-fourths Rs, $Sc_2$ near its tip; m-cu before fork of M.

Abdominal tergites and subterminal sternites brown, basal sternites yellow. Male hypopygium (Plate 5, fig. 48) with the tergite, *t*, transverse, narrowed outwardly, the posterior end extended into the proctigeral area, without lobes, the thickened margins narrow. Basistyle, *b*, with ventromesal lobe oval. Dorsal dististyle slender, the acute tip strongly decurved. Ventral dististyle, *d*, slightly larger than the basistyle; rostral prolongation conspicuous, spines two, slightly separated, shorter than the prolongation beyond their insertion. Gonapophysis, *g*, with mesal-apical lobe darkened, slender, gently curved, tip subacute. Ædeagus glabrous, terminating in two oval lobes.

*Habitat.*—Assam.

Holotype, male, Nongrim, Khasi-Jaintia, altitude 3,000 feet, March 28, 1960 (*Schmid*). Allotype, female, Mawkhap, Khasi-Jaintia, altitude 2,000 feet, Mrach 19, 1960 (*Schmid*).

*Limonia ushas* superficially suggests species such as *L. punctticosta* (Brunetti) which actually is quite distinct, especially in the male hypopygium which has four rostral spines.

LIMONIA VIBHISHANA sp. nov. Plate 2, fig. 19; Plate 5, fig. 49.

Allied to *flavocincta;* general coloration of thorax yellow and black; front broad, silvery; legs brownish black; posterior tarsi pale yellow; wings weakly infuscated, restrictedly patterned with brown; abdomen black, posterior borders of segments pale yellow; male hypopygium with ventral dististyle having a single rostral spine; gonapophysis slender, unequally bidentate.

*Male.*—Length, about 6 millimeters; wing, 6.8; antenna, about 2.0

Rostrum and papli black, relatively short. Antennæ relatively long, black; basal flagellar segments oval, outer ones more elongate, all with short abrupt apical pedicels, terminal segment elongate, about one-third longer than the penultimate. Front and broad anterior vertex silvery, the latter about four times the diameter of scape. Head dull black.

Pronotum reduced, brownish black. Mesonotal præscutum with disk covered by a confluent shield, brown in front, blackened posteriorly, continued laterad to border and thence as a slightly interrupted transverse band across the mesepisternum; posterior sclerites of notum yellowed, including the narrow posterior border of præscutum adjoining the suture; central region of scutum, scutellum and broad central area of mediotergite yellowed; scutal lobes and sides of postnotum blackened; surface of præscutum microscopically reticulate. Pleura yellow, with almost continuous brownish black areas on anepisternum and ventral sternopleurite. Halteres blackened. Legs with coxæ and trochanters yellow, the fore coxæ weakly infuscated; remainder of legs brownish black, posterior tarsi pale yellow, involving segments two to four, the pale color vaguely indicated on fore and middle tarsi. Wings (Plate 2, fig. 19) weakly infuscated; stigma oval, dark brown; very narrow and inconspicuous brown seams at origin of Rs, cord, outer end of cell 1st $M_2$ and along vein Cu; veins brown. Venation: Sc long, $Sc_1$ ending nearly opposite midlength of Rs, $Sc_2$ near its tip; free tip of $Sc_2$ and $R_2$ nearly in transverse alignment, $R_{1+2}$ projecting beyond as a subequal spur that is provided with three trichia; m-cu shortly beyond fork of M, longer than distal section of $Cu_1$.

Abdomen, including hypopygium, black posterior borders of segments broadly pale yellow, more conspicuous on sternites. Male hypopygium (Plate 5, fig. 49) with the tergite, *t*, transverse, narrowed outwardly, posterior border almost truncate, margins scarcely thickened; surface with abundant setulæ, the setæ numerous across disk, lacking on border. Basistyle, *b*, with ventromesal lobe oval, with abundant setæ. Dorsal dististyle stout, gently curved to the acute tip. Ventral dististyle, *d*, small, its area only about one-third that of the basistyle; rostral prolongation slender, sclerotized, with a single strong spine from a stout basal tubercle; tip beyond the spines produced into a pendant point, with two strong setæ on outer margin. Gonapophysis, *g*, with mesal-apical lobe slender, unequally bifid, there being a small lateral spine additional to the much longer apical point. Ædeagus narrow, terminating in two short-tubular points.

*Habitat.*—Ceylon.

Holotype, male, Ambawela, altitude 6,000 feet, March 6, 1954 (*Schmid*).

The most similar species is *Limonia flavocincta* (Brunetti) (*whitei* Alexander) which differs in details of hypopygial structure, especially the ædeagus and gonapophyses.

LIMONIA (RHIPIDIA) CRASSIROSTRIS sp. nov. Plate 2, fig. 20; Plate 5, fig. 50.

General coloration gray; antennæ of male with six short-branched flagellar segments, longest branches subequal to the segments; legs pale yellowish brown; wings subhyaline, with an abundant but inconspicuous dotted gray pattern, $Sc_2$ ending about opposite one-fifth Rs; male hypopygium with rostral prolongation of ventral dististyle stout, tip short and obtuse, seven to nine very long curved spines.

*Male.*—Lengths, about 6.5 millimeters; wing, 7.3; antenna, about 1.5

Rostrum relatively long, especially the labial palpi, nearly equal to remainder of head. Antennæ dark brown, the apical pedicels of the flagellar segments paler; flagellar segments two to seven bipectinate, the branches very short, the longest subequal to the segment; first flagellar segment merely produced, eighth segment with a single branch that is nearly as long as the segment, ninth segment merely produced; outer three segments simple, the tenth and eleventh subglobular, terminal segment strongly narrowed apically. Head brown; anterior vertex narrow.

Pronotum light brown. Mesonotum gray, the præscutum and scutum of type discolored, apparently patterned with brown. Pleura gray, posteriorly with a narrow darker longitudinal stripe. Halteres with stem obscure yellow, knob a little darker. Legs with coxæ and trochanters testaceous yellow; remainder of legs pale yellowish brown, outer tarsal segments darker; claw with a single well-developed spine. Wings (Plate 2, fig. 20) subhyaline, with an abundant but very inconspicuous dotted gray pattern, the dots oval to circular, not evidently confluent; very small darker spots in cell Sc at near midlength; veins pale brown. Venation: Sc relatively short, $Sc_1$ about opposite one-fifth Rs; cell 1st $M_2$ long, subequal to distal section of $M_3$, the tip of the latter atrophied in both wings of type; m-cu about one-third its length before fork of M.

Abdomen brown. Male hypopygium (Plate 5, fig. 50) with the tergite, *t*, transverse, posterior border very shallowly emarginate, lobes low with thickened borders; setæ long, pale. Basistyle, *b*, with ventromesal lobe oval, all setæ pale and inconspicuous. Dorsal dististyle a stout rod, slightly more

expanded before the straight apical spine. Ventral dististyle, *d*, fleshy, its total area about one-half greater than that of the basistyle, setæ pale; rostral prolongation stout, apex obtusely rounded; from seven to nine very long curved rostral spines arranged in a compact group, longest spines only a little shorter than the prolongation, all much longer than the part beyond their insertion. Gonapophysis, *g*, with mesal-apical lobe blackened, nearly straight, tip curved laterad.

*Habitat.*—Kumaon.

Holotype, male, Rata, Almora, altitude 11,000 feet, in *Rhododendron* association, September 14, 1958 (*Schmid*).

*Limonia* (*Rhipidia*) *crassirostris* may be told from the most similar regional species, *L.* (*R.*) *subtesselata* (Brunetti) and *L.* (*R.*) *synspilota* Alexander, by the structure of the male antennæ and hypopygia. The short obtuse apex of the rostral prolongation of the ventral dististyle and the numerous elongate rostral spines provide strong characters for the recognition of the species.

LIMONIA (RHIPIDIA) HARIOLA sp. nov. Plate 2, fig. 21; Plate 5, fig. 51.

Belongs to the *rostrifera* group; mesonotal præscutum with three dark brown stripes, pleura yellow, with two conspicuous longitudinal blackened stripes; knobs of halteres brownish black; extreme tips of femora yellowed; wings cream yellow, with a heavy brown pattern, basad of cord without darkenings except at arculus and origin of Rs; abdomen obscure yellow, posterior borders of segments silvery gray, more evident on the sternites; male hypopygium with the two rostral spines from a conspicuous basal tubercle.

*Male.*—Length, about 5.5 to 6.5 millimeters; wing, 5.5 to 6; antenna, about 14 to 1.5.

*Female.*—Length, about 5.5 to 6 millimeters; wing, 6.

Rostrum moderately elongate, subequal to remainder of head, black throughout; palpi black. Antennæ in male with scape and pedicel obscure yellow, flagellar segments yellowed, branches black, on outer segments the basal enlargements similarly blackened; flagellar segments one to eleven each with two long branches, the longest exceeding twice the segment, terminal segment simple. In female, antennæ simple, flagellar segments entirely black, with very short apical pedicels, terminal segment nearly twice the penultimate. Head dark brown, yellowish gray pruinose; anterior vertex broad, about four times the diameter of scape.

Cervical region and pleura of prothorax blackened. Mesonotal præscutum yellow pollinose, with three dark brown stripes; scutal lobes darkened, median region and scutellum brownish yellow, with pale pollen; postnotum brownish black. Pleura yellow pollinose, with two conspicuous blackened longitudinal stripes, the dorsal one extending from cervical region to dorsal postnotum, lower stripe on ventral sternopleurite. Halteres with stem light yellow, knob brownish black. Legs with coxæ and trochanters yellow; femora yellow, with a broad brown nearly terminal ring, extreme tip yellow; tibiæ brown, tips narrowly darker; tarsi yellowish brown; claws with a single major spine. Wings (Plate 2, fig. 21) cream yellow, prearcular and costal fields more saturated yellow; a conspicuous brown pattern, including arculus, $Sc_2$, tip of $Sc_1$ and origin of Rs, stigma, this confluent with a band at cord, fork of $M_{3+4}$ a major darkening in outer ends of cells $R_2$ and $R_3$; weak marginal clouds on medial veins; veins yellow, pale brown in the patterned areas. Outer longitudinal veins from $R_3$ to $M_3$ with trichia. Venation: $Sc_1$ ending just beyond origin of Rs, $Sc_2$ far retracted; cell $M_2$ open by atrophy of m; m-cu just beyond fork of M.

Abdominal tergites obscure yellow, lateral borders narrowly brown, posterior margins paler; sternites obscure yellow, lateral borders brown, posterior margins of segments two to six broadly silvery gray; hypopygium brownish yellow. Ovipositor with genital segment light brown, bases of hypovalvæ black; cerci and hypovalvæ horn colored, the former very slender, gently upcurved to the acute tips. Male hypopygium (Plate 5, fig. 51) with tergite, *t*, transverse, posterior border with a shallow V-shaped emargination, lobes broadly obtuse. Basistyle, *b*, with ventromesal lobe large, about one-half the body of style. Dorsal dististyle a slender rod, outer half slightly curved, terminating in a long spine. Ventral dististyle, *d*, in area about one-third to one-half greater than that of basistyle; rostral prolongation relatively short, apex obtuse, on outer margin with a stout tubercle tipped with two slender spines, these about twice the length of the tubercle. Gonapophysis, g, with mesal-apical lobe slender. Ædeagus narrow, apical lobes small, oval.

*Habitat.*—Assam.

Holotype, male, Serrarim, Khasi-Jaintia, altitude 5,500 feet, October 7, 1960 (*Schmid*). Allotype, female, Dympap, Khasi-

Jaintia, altitude 6,000 feet, October 1, 1960. Paratopotype, one male; paratypes, one male, one female, Mawrap, Khasi-Jaintia, altitude 4,800 feet, October 2, 1960; one male, Umsawnot, Khasi-Jaintia, altitude 4,500 feet, October 5, 1960 (*Schmid*).

*Limonia* (*Rhipidia*) *hariola* is quite distinct from all previously described members of the *rostrifera* group in its wing pattern, being about intermediate between *L.* (*R.*) *rostrifera* (Edwards) and *L.* (*R.*) *garrula* Alexander and allied species. As suggested earlier in this paper, the structure of the male hypopygium is much as in species of the subgenus *Dicranomyia* Stephens, having only two rostral spines, presuming a separate origin from the typical members of the subgenus, the *lecontei* group.

LIMONIA (RHIPIDIA) UGRA sp. nov. Plate 2, fig. 22; Plate 5, fig. 52.

Mesonotum brown and gray, thoracic pleura with a broad darker brown longitudinal stripe; antennal flagellum of male short-unipectinate; femora blackened outwardly, the fore pair more extensively so; wings with the whitened ground very restricted, the surface with extensive confluent brown clouds and spots; costal region yellowed, with four more extensive brown areas, including the stigma; male hypopygium with rostral prolongation of ventral dististyle slender, with three relatively short spines.

*Male.*—Length, about 7 millimeters; wing, 8; antenna, about 1.3.

Rostrum and palpi black. Antennæ black, apical pedicels of intermediate flagellar segments yellow; flagellar segments two to ten each with a single short branch, the longest scarcely exceeding the segment, obtuse at tip; outer five segments with the branch gradually reduced in size, finally merely produced; terminal segment about one-half longer than the penultimate. Head brownish gray; anterior vertex narrow, less than the diameter of the scape.

Pronotum dark brown. Mesonotal præscutum extensively medium brown, lateral borders broadly light gray; posterior sclerites brown, central portions dusted with gray. Pleura brown, with a broad darker brown longitudinal stripe extending from the cervical region to base of abdomen; dorsopleural region light yellow, ventral sternopleurite more obscure yellow. Halteres yellow, knobs vaguely suffused. Legs with coxæ yellowish brown; trochanters yellow; fore femora blackened,

bases narrowly yellowed, remaining femora extensively yellowed, tips narrowly darkened, remainder of legs dark brown; claws with a single well-developed spine. Wings (Plate 2, fig. 22) with the restricted ground whittened, appearing as small dots between the extensive brown spots and clouds, the latter chiefly confluent; costal border more yellowed, with four very extensive brown areas that reach vein M behind, the yellow interspaces very restricted; veins brown, C, Sc and R light yellow. Venation: $Sc_1$ ending about opposite one-fourth to one-fifth Rs; cell 1st $M_2$ subequal in length to vein $M_4$; m-cu shortly before fork of M.

Abdominal tergites brown, narrowly darker laterally, basal sternites obscure brownish yellow; ventral dististyle of hypopygium yellowed. Male hypopygium (Plate 5, fig. 52) with tergite, *t*, transverse, very gradually narrowed outwardly, posterior border very shallowly emarginate, all borders thickened; tergal setæ about 15 on each lobe. Basistyle, *b*, with ventromesal lobe obtuse, with long setæ. Dorsal dististyle blackened, gradually narrowed to the long acute tip. Ventral dististyle, *d*, subequal in area to the basistyle; rostral prolongation elongate, with three small spines, these shorter than the prolongation beyond their insertion. Gonapophysis, *g*, with mesal apical lobe blackened, straight, terminating in a small rounded lobe. Ædeagus with apical lobes small, divergent.

*Habitat.*—Kumaon.

Holotype, male, Rata, Almora, altitude 11,000 feet, in *Rhododendron* association, September 14, 1958 (*Schmid*).

Other regional members of the subgenus having unipectinate flagellar segments, such as *Limonia* (*Rhipidia*) *monophora* Alexander, differ conspicuously in the coloration of the body, legs and wings, as well as the structure of the male hypopygium. The lengthened rostral prolongation of the ventral dististyle, with three short spines, is suggestive of the condition in the otherwise very different *L.* (*R.*) *choprai* Alexander, with the male flagellum bipectinate.

### LIMONIA: MELANOLIMONIA subgen. nov.

General coloration of thorax commonly polished black, more rarely (as in *fulvomorio, kongosana, lakshmi, spinifera*) polished brown or fulvous, pleura extensively silvery pruinose. Anterior vertex very broad, bright silvery, the width approximately four times the diameter of the antennal scape. Antennæ with terminal segment commonly elongate, more or

less constricted at near midlength. Wings with vein $Sc_1$ very long, approximately one-half Rs or more; cell 1st $M_2$ closed. Male hypopygium with the tergite variable, ranging from having the posterior border nearly truncate, without evident lobes, to profoundly emarginate, forming slender fingerlike lobes. Dorsal dististyle commonly a simple curved sickle, its tip acute, in cases (*pseudomorio* and several others) with the apex expanded, more or less bispinous. Ventral distitsyle commonly with a single pale cylindrical or peglike spine placed in a membranous area, somewhat as in *Discobola;* in cases (including *morio*) without a rostral spine. Ninth sternite a distinct oval or semicircular plate with several strong marginal setæ, somewhat as in *Geranomyia* and some other subgenera. Ædeagus conspicuously expanded, outer end with abundant scabrous points and setæ.

Type of subgenus: *Limonia* (*Melanolimonia*) *morio* (Fabricius). Palaearctic.

Other species include *L.* (*H.*) *morioides* (Osten Sacken), *L.* (*M.*) *neomorio* (Alexander), *L.* (*M.*) *nycteris* (Alexander), *L.* (*M.*) *spinifera* (Alexander), Nearctic; *L.* (*M.*) *caledonica* Edwards, *L.* (*M.*) *hamata* (Becker), *L.* (*M.*) *occidua* Edwards, *L.* (*M.*) *rufiventris* (Strobl), *L.* (*M.*) *stylifera* (Lackschewitz), *L.* (*M.*) *tyrrhenica* (Edwards), Western Palaearctic; *L.* (*M.*) *aurita* Alexander, *L.* (*M.*) *benguetensis* Alexander, *L.* (*M.*) *emodi* Alexander, *L.* (*M.*) *fulvomorio* Edwards, *L.* (*M.*) *fulvonigrina* sp. nov., *L.* (*M.*) *kansuensis* Alexander, *L.* (*M.*) *kongosana* Alexander, *L.* (*M.*) *lakshmi* Alexander, *L.* (*M.*) *moronis* Alexander, *L.* (*M.*) *nankaidoensis* Alexander, *L.* (*M.*) *nesomorio* (Alexander), *L.* (*M.*) *nigrithorax* (Brunetti), *L.* (*M.*) *nitidithorax* (Senior-White), *L.* (*M.*) *pacifera* Alexander, *L.* (*M.*) *paramorio* (Alexander), *L.* (*M.*) *paramorio platysoma* Alexander, *L.* (*M.*) *parviloba* Alexander, *L.* (*M.*) *penita* Alexander, *L.* (*M.*) *pernigrita* sp.nov., *L.* (*M.*) *pseudomorio* (Alexander), *L.* (*M.*) *subaurita* Alexander, *L.* (*M.*) *submorio* (Alexander), eastern Palaearctic and Oriental.

The present group is proposed for members of the so-called *morio* group, hitherto placed in *Dicranomyia,* but long realized to be unusually distinct. The range of the various species includes the Holarctic region, with rather numerous forms ranging south into the Oriental, with several occurring in Formosa, Luzon, Mindanao, and Borneo.

**LIMONIA (MELANOLIMONIA) FULVONIGRINA sp. nov.** **Plate 2, fig. 23; Plate 5. fig. 53.**

Size large (wing of male over 8 millimeters); mesonotum obscure yellow, præscutum with three confluent polished black stripes; femora yellow, tips rather narrowly brown; wings strongly brownish yellow, stigma elongate, brown; Rs long, nearly two and one-half times $R_{2+3}$; abdominal tergites brownish black, posterior borders yellowed; male hypopygium with tergal lobes broader than the intervening emargination, setæ relatively short; ventral dististyle apparently without a rostral spine; ædeagus broad.

*Male.*—Length, about 8 millimeters; wing, 8.5.

Rostrum and palpi dark brown. Antennæ brown; basal flagellar segments oval, the outer ones progressively more elongate; terminal segment very long, nearly twice the penultimate, constricted at near midlength; longest verticils exceeding the segments. Head brown.

Pronotum blackened medially, brownish gray pruinose on sides. Mesonotal præscutum with sides broadly obscure yellow, disk with three confluent polished black stripes, the central one vaguely divided medially in front, ending far before suture; posterior sclerites of notum obscure yellow, scutal lobes brownish black. Propleura dark brown, remainder of pleura yellowed, faintly silvery pruinose. Halteres with stem yellow, knob brownish black. Legs with coxæ and trochanters yellow; femora yellow, tips rather narrowly dark brown; tibiæ and proximal segments of tarsi obscure yellow, outer segments blackened; claws elongate with a slender basal spine. Wings (Plate 2, fig. 23) strongly suffused with brownish yellow, stigma elongate, brown; veins brown, those of proximal third more yellowed. Venation: $Sc_1$ ending opposite origin of Rs, the latter long, nearly straight, about two and one-half time $R_{2+3}$.

Abdominal tergites brownish black, posterior borders conspicuously yellow; sternites more uniformly brownish yellow; hypopygium brown, basistyles black. Male hypopygium (Plate 5, fig. 53) with lobes of tergite, *t*, darkened, stout, broader than the intervening emargination, setæ relatively short and stout (as compared with *nigrithorax*). Basistyle, *b*, with ventromesal lobe large, obtusely rounded. Dorsal dististyle slightly widened before the acute tip. Ventral dististyle, *d*, subequal in area to basistyle; rostral prolongation slender, apparently without a spine, as in *nigrithorax;* if this normally is present, the type specimen has lost it on both styles. Gona-

pophysis, *g*, pale, mesal-apical lobe curved, tip subacute. Ædeagus broad, margins and subapical lobes with abundant microscopic scabrous points, with small interpolated setæ.

*Habitat.*—Sikkim.

Holotype, male, Lachung, altitude 8,610 feet, July 9, 1959 (*Schmid*).

The closest ally is *Limonia* (*Melanolimonia*) *nigrithorax* (Brunetti) which has the mesonotum uniformly blackened and differs in other colorational and slight hypopygial features.

**LIMONIA (MELANOLIMONIA) PERNIGRITA sp. nov.** Plate 2, fig. 24; Plate 5, fig. 54.

Size small (wing of male 6 millimeters); general coloration of mesonotum intense polished black, pleura extensively silvery; fore legs black, middle and hind femora paler; wings weakly infuscated, base yellowed, stigma brown, conspicuous; abdomen black; male hypopygium with tergal lobes very slender, widely separated; ventromesal lobe of basistyle blackened, narrowed to a point, with the strong apical bristles; no resortal spine; gonapophysis blackened, very broadly triangular.

*Male.*—Length, about 5.5 millimeters; wing, 6.

Rostrum, palpi and antennæ black; proximal flagellar segments subglobular, shorter than the verticils, outer segments longer, terminal segment about one-third longer than the penultimate. Anterior vertex broad, light silvery, posterior part of head black.

Thoracic dorsum intense polished black, scutellum slightly more opaque, pleura black, mesopleura and meron silvery. Halteres with stem brownish yellow, base clearer yellow, knob brownish black. Legs with coxæ blackened, posterior pair more pruinose, tips narrowly yellowed; trochanters obscure yellow; fore legs black; middle femora dark brown, posterior femora yellow, slightly darkened at tip; tibiæ brown, tarsi passing into black; claws with a long straight basal spine and smaller denticles. Wings (Plate 2, fig. 24) weakly infuscated, base yellowed; stigma oval, darker brown, conspicuous; veins brown, prearcular veins and Sc yellowed. Veins Rs, outer radial veins and distal section of $M_3$ with long black trichia, with about two others at end of vein 2nd A. Venation: Sc short, $Sc_1$ ending a short distance before origin of Rs, $Sc_1$ shorter than Rs; m-cu shortly before fork of M.

Abdomen, including hypopygium, black. Male hypopygium (Plate 5, fig. 54) with tergite, *t*, large, very gradually narrowed

outwardly, posterior border produced into two widely separated fingerlike lobes that are provided with a few long setæ, the emargination between lobes very broad. Basistyle, *b*, with ventromesal lobe elongate, basal in position, narrowed outwardly to a point, with a strong apical bristle and a second immediately before tip. Dorsal dististyle a strongly curved, black sickle, very gradually narrowed to an acute tip. Ventral dististyle, *d*, with body small, provided with very long coarse bristles; rostrum elongate, slightly widened outwardly, with sparse setæ, lacking the rostral spine. Gonapophysis, *g*, blackened, very broadly triangular. Ædeagus, *a*, broad, outer part with abundant long pale setæ.

*Habitat.*—Sikkim.

Holotype, male, Yedang, altitude 10,600 feet, in *Rhododendron* association, June 9, 1959 (*Schmid*).

*Limonia* (*Melanolimonia*) *pernigrita* is quite distinct from other generally similar regional species, such as *L.* (*M.*) *lakshmi* Alexander and *L.* (*M.*) *nigrithorax* (Brunetti), particularly in the structure of the male hypopygium. The very slender tergal lobes are generally similar to those found in certain other Asiatic species, as *L.* (*M.*) *aurita* Alexander and *L.* (*M.*) *pseudomorio* (Alexander), but the further hypopygial structures are quite distinct.

LIMONIA (PSEUDOGLOCHINA) APICIALBA sp. nov. Plate 2, fig. 25.

General coloration of mesonotum brown, with a conspicuous pale central stripe that is widened behind, pleura chiefly whitened; femora black, tips narrowly whitened, tibiæ white, with a single very narrow dark ring beyond midlength; wings pale yellow, conspicuously patterned with brown.

*Male.*—Length, about 4.8 millimeters; wing, 5.2.

Rostrum obscure yellow, mouthparts and palpi black. Antennæ black; flagellar segments strongly nodulose, with conspicuous apical pedicels; each segment with a single unilaterally distributed verticil and numerous coarse setæ that are nearly as long; proximal flagellar segments oval, outer ones more elongate, terminal segment a little shorter than the penultimate. Front and anterior vertex yellowed, dark brown between the eyes, posterior part of head extensively brownish yellow; anterior vertex relatively broad, a little less than the diameter of scape.

Prothorax and pretergites whitened, the pronotum weakly suffused with pale brown. Mesonotum brown, lateral præscutal border narrowly darker brown; a conspicuous pale central stripe from posterior part of præscutum, widened posteriorly, including most of mediotergite, the sides adjoining the wing root darker brown. Pleura with a very broad whitened stripe that include the dorsopleural membrane, ventral sternopleurite blackened. Halteres with stem light yellow, knob brownish black. Legs with fore coxæ pale yellow, middle and hind coxæ dark brown, bases pale; all trochanters black; femora black, the tips narrowly whitened, with only a microscopic darkening at extreme apex; tibiæ white with a single very narrow brown ring just beyond midlength; tarsi white; claws long, setiferous on outer face at base, with a long hairlike basal spine. Wing (Plate 2, fig. 25) very yellow, prearcular and costal margins slightly more yellowed, including the costa; a conspicuous dark brown pattern that includes the large oval stigma and a major area at origin of Rs and tip of Sc; slightly paler brown areas at fork of Rs, cord, outer medial fork and a marginal cloud at end of $R_3$; less evident paler suffusions along Cu, $R_{4+5}$ and at tip of $Cu_1$; veins light brown, scarcely darker in the patterned areas, yellow in the brightened fields. Longitudinal veins beyond cord with very abundant relatively short trichia, with a few others at ends of M and basal section of $Cu_1$, lacking on Sc and the anals. Venation: $Sc_1$ ending nearly opposite fork of Rs, $Sc_2$ near its origin; Rs and basal section of $R_{4+5}$ subequal; cell 2nd $M_2$ nearly twice its petiole; m-cu close to fork of M; vein 2nd A strongly sinuous, its base not confluent with posterior border of wing.

Abdominal tergites brownish yellow, basal sternites yellow, intermediate sternites with a large brown area on either side at base, subterminal segments more uniformly pale; hypopygium small, pale brown.

*Habitat.*—Assam.

Holotype, male, Singkap, Manipur, altitude 3,800 feet, August 16, 1960 (*Schmid*).

The only other regional member of the subgenus having a single darkened tibial ring is *Limonia* (*Pseudoglochina*) *periscelis* Alexander, of Nepal, readily told by the blackened femoral tips and unpatterned wings. No other member of the subgenus so far discovered has this combination of characters.

LIMONIA (PSEUDOGLOCHINA) EURYMELANIA sp. nov Plate 2, fig. 26.

Mesonotal præscutum light cinnamon brown, scutal lobes dark brown, posterior sclerites of notum testaceous yellow, pleura almost uniformly pale yellow, ventral sternopleurite very narrowly dark brown; fore femora black, tibiæ snowy white with two broad black rings, the wider outer band nearly twice the white tip, tarsi snowy white; abdomen dark brown, posterior disks of segments more yellowed.

*Female.*—Length, about 7.5 millimeters; wing, 6.9.

Rostrum and papli black. Antennæ black; flagellar segments long-oval, with long apical pedicels, longest verticils exceeding the segments, shorter proportionally than in *bilatior* or *bilatissima*. Head with center of posterior vertex light fulvous, anterior vertex and orbits light gray; anterior vertex broad.

Pronotum and cervical region yellow. Mesonotal præscutum light cinnamon brown, only the lateral borders slightly darker; scutal lobes dark brown, the median area, scutellum and central part of mediotergite testaceous yellow, the last slightly darker on sides. Pleura almost uniformly pale yellow, only the ventral sternopleurite dark brown. Halteres dark brown. Fore legs with coxæ yellow, trochanters blackened; femora black, bases narrowly brightened; tibiæ snowy white, with two broad black rings, the basal one only about one-third as wide as the outer, the latter about twice the white apex and one-third more extensive than the white interspace; tarsi snowy white; middle and hind legs with coxæ and trochanters yellow, remainder broken. Wings (Plate 2, fig. 26) very faintly tinged with brown, stigma oval, dark brown; veins dark brown. Longitudinal veins beyond cord with abundant long macrotrichia; basad of cord trichia on more than outer third of M, with one or few at end of $Cu_1$; no trichia on Sc or anals. Venation: $Sc_1$ ending immediately beyond origin of Rs, $Sc_2$ retracted, $Sc_1$ nearly as long as Rs; cell 2nd $M_2$ nearly three times its petiole; m-cu at fork of M; vein 2nd A arched.

Abdomen dark brown, the disks of outer parts of segments more yellowed. Ovipositor with cerci very slender, almost straight.

*Habitat.*—Assam.

Holotype, female, Phaileng, Lushai Hills, Mizo District, altitude 3,500 feet, September 14, 1960 (*Schmid*).

The present fly is very different from other regional species in the unusually broad and conspicuous black tibial rings, in this respect being more like the Philippine *Limonia* (*Pseudoglochina*) *bilatior* Alexander and *L.* (*P.*) *bilatissima* Alexander, which differ evidently in the details of coloration of the body and legs and in the structure of the antennæ.

## REFERENCES

ALEXANDER, C. P. The interpretation of the radial field of the wing in the Nematocerous Diptera, with special reference to the Tipulidæ. Proc. Linn. Soc. New South Wales 52 (1927) 42–72, 92 figs.; 1927a.

ALEXANDER, C. P. The Oriental Tipulidæ in the collection of the Indian Museum. Part 1. Rec. Indian Mus. 29 (1927) 167–224, 1 pl., 23 figs.; 1927 b.

ALEXANDER, C. P. New or little-known Tipulidæ from the Philippines (Diptera), V. Philip. Jour. Sci. 40 (1929) 239–273, 1 plate with 18 figs.; 1929 a.

ALEXANDER, C. P. A comparison of the systems of nomenclature that have been applied to the radial field of the wing in the Diptera. IV. Internat. Congress Ent. 2 (1929) 700–707, 3 pls.; 1929 b.

ALEXANDER, C. P. New or little-known Tipulidæ from eastern Asia (Diptera), XXI. Philip. Jour. Sci. 55 (1934) 19–60, 3 pls. (reference pp. 38–39); 1934 a.

ALEXANDER, C. P. In C. H. Curran's The families and genera of North American Diptera (1934), refs. pp. 38–39; 1934 b.

ALEXANDER, C. P. New or little-known Tipulidæ from Eastern Asia Diptera), XXXII. Philip. Jour. Sci. 61 (1936) 113–149 (subgenus *Gressittomyia* Alexander).

ALEXANDER, C. P. Notes on the tropical American species of Tipulidæ (Diptera), VI. The tribe Limoniini, genus Limonia; subgenera Limonia, Neolimnobia, Discobola and Rhipidia. Rev. de Entomologia 21 (1950) 161–221, 42 figs.

ALEXANDER, C. P. New or little-known Tipulidæ (Diptera). CI. Oriental-Australasian species. Ann. Mag. Nat. Hist. (12) 9 (1956) 145-163 (subgenus Degeneromyia Alexander).

BERGROTH, E. Some Tipulid synonymy. Psyche 22 (1915) 54–55.

EDWARDS, F. W. British short-palped craneflies. Taxonomy of adults. Trans. Soc. Brit. Ent. 5 (1938) 1–168, 5 pls. 31 figs.

OSTEN SACKEN, C. R. Studies on Tipulidæ. Part II. Review of the published genera of Tipulidæ brevipalpi. Berlin. Entomol. Zeitschr. 31 (1887) 163–242.

# ILLUSTRATIONS

[Legend: *a*, aedeagus; *b*, basistyle; *d*, dististyle; *g*, gonapophysis; *l*, labial palpus; *m*, maxillary palpus; *t*, tergite.]

PLATE 1

FIG. 1. *Limonia* (*Limonia*) *devata* sp.nov.; venation.
2. *Limonia* (*Limonia*) *acinacis* sp.nov.; venation.
3. *Limonia* (*Limonia*) *bifaria* sp.nov., venation.
4. *Limonia* (*Limonia*) *brachylabis* sp.nov., venation.
5. *Limonia* (*Limonia*) *tanyrhyncha* sp.nov.; venation.
6. *Limonia* (*Limonia*) *anteterminalis* sp.nov.; venation.
7. *Limonia* (*Metalimnobia*) *brahma* sp.nov.; venation.
8. *Limonia* (*Metalimnobia*) *xanthopteroides adonis* subsp.nov.; venation.
9. *Limonia* (*Libnotes*) *pramatha* sp.nov., venation.
10. *Limonia* (*Libnotes*) *sharva* sp.nov.; venation.
11. *Limonia* (*Libnotes*) *tartarus* sp.nov.; venation.
12. *Limonia aspropoda* sp.nov.; venation.
13. *Limonia bhima* sp.nov.; venation.
14. *Limonia indefessa* sp.nov.; venation.
15. *Limonia luteipostica* sp.nov.; venation.
16. *Limonia luteitarsis* sp.nov.; venation.
17. *Limonia pernodosa* sp.nov.; venation.
18. *Limonia ushas* sp.nov.; venation.

PLATE 2

FIG. 19. *Limonia vibhishana* sp.nov.; venation.
20. *Limonia* (*Rhipidia*) *crassirostris* sp.nov.; venation.
21. *Limonia* (*Rhipidia*) *hariola* sp.nov.; venation.
22. *Limonia* (*Rhipidia*) *ugra* sp.nov.; venation.
23. *Limonia* (*Melanolimonia*) *fulvonigrina* sp.nov.; venation.
24. *Limonia* (*Melanolimonia*) *pernigrita* sp.nov.; venation.
25. *Limonia* (*Pseudoglochina*) *apicialba* sp.nov.; venation.
26. *Limonia* (*Pseudoglochina*) *curymelania* sp.nov.; venation.
27. *Limonia* (*Limonia*) *devata* sp.nov.; male hypopygium.
28. *Limonia* (*Limonia*) *acinacis* sp.nov.; male hypopygium.
29. *Limonia* (*Limonia*) *bifaria* sp.nov.; male hypopygium.
30. *Limonia* (*Limonia*) *hostilis* Alexander; male hypopygium.

PLATE 3

FIG. 31. *Limonia* (*Limonia*) *brachylabis* sp.nov.; mouthparts.
32. *Limonia* (*Limonia*) *stenolabis* sp.nov.; mouthparts.
33. *Limonia* (*Limonia*) *tanyrhyncha* sp.nov.; mouthparts.
34. *Limonia* (*Limonia*) *brachylabis* sp.nov.; male hypopygium.
35. *Limonia* (*Limonia*) *tanyrhyncha* sp.nov.; male hypopygium.
36. *Limonia* (*Limonia*) *anteterminalis* sp.nov.; male hypopygium.
37. *Limonia* (*Metalimnobia*) *brahma* sp.nov.; bale hypopygium.
38. *Limonia* (*Metalimnobia*) *xanthopteroides adonis* subsp.nov.; male hypopygium.



031610——11

PLATE 4

FIG. 39. *Limonia* (*Libnotes*) *pramatha* sp.nov.; male hypopygium.
40. *Limonia* (*Libnotes*) *sharva* sp.nov.; made hypopygium.
41, 42. *Limonia aspropoda* sp.nov.; male hypopygium.
43. *Limonia bhima* sp.nov.; male hypopygium.
44. *Limonia indefessa* sp.nov.; male hypopygium .
45. *Limonia luteipostica* sp.nov.; male hypopygium.
46. *Limonia luteitarsis* sp.nov.; male hypopygium.

PLATE 5

FIG. 47. *Limonia pernodosa* sp.nov.; male hypopygium.
48. *Limonia ushas* sp.nov.; male hypopygium.
49. *Limonia vibhishana* sp.nov.; male hypopygium.
50. *Limonia* (*Rhipidia*) *crassirostris* sp.nov.; male hypopygium.
51. *Limonia* (*Rhipidia*) *hariola* sp.nov.; male hypopyguim.
52. *Limonia* (*Rhipidia*) *ugra* sp.nov.; male hypopygium.
53. *Limonia* (*Melanolimonia*) *fulvonigrina* sp.nov.; male hypopygium
54. *Limonia* (*Melanolimonia*) *pernigrita* sp.nov.; male hypopygium.

○

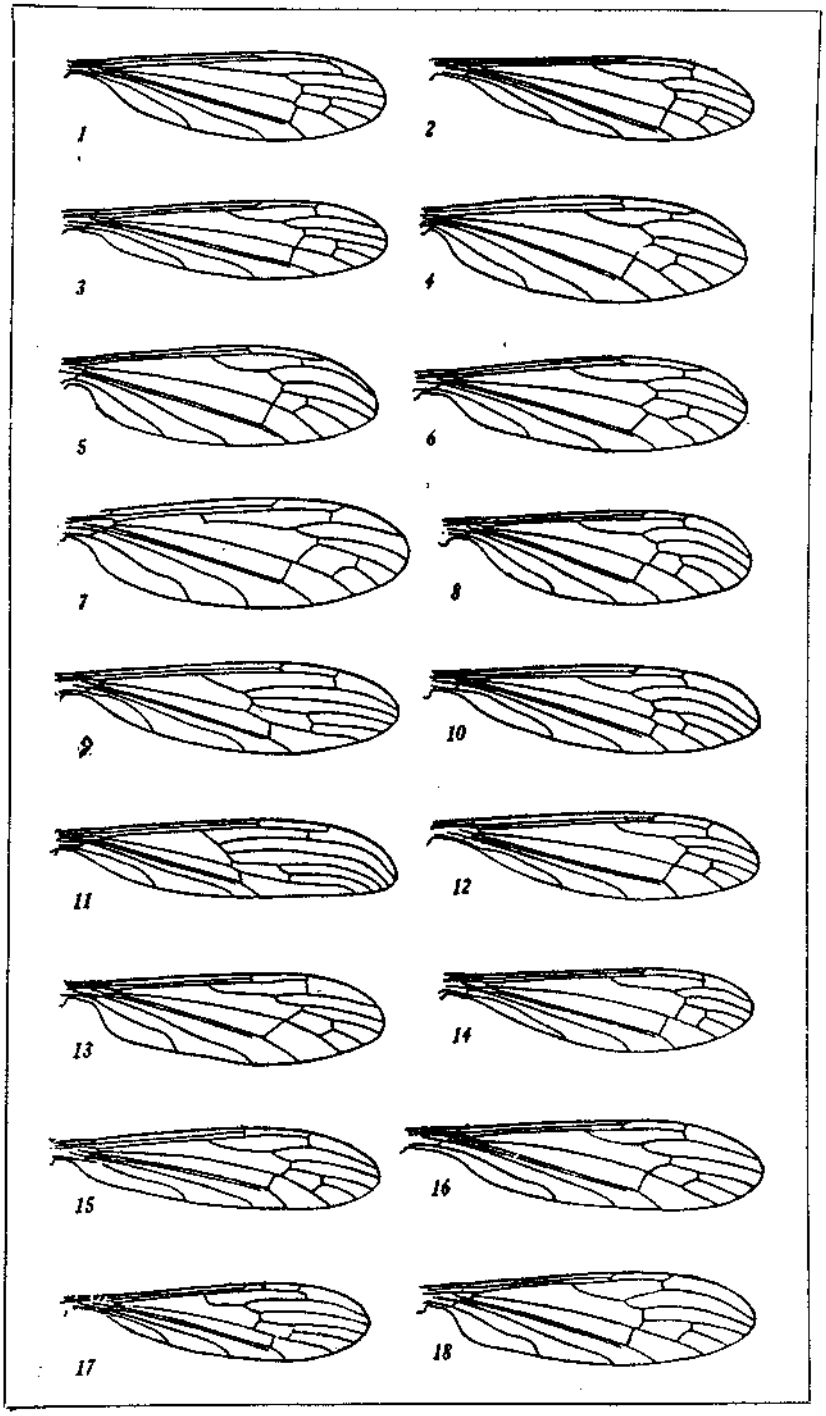



PLATE 1

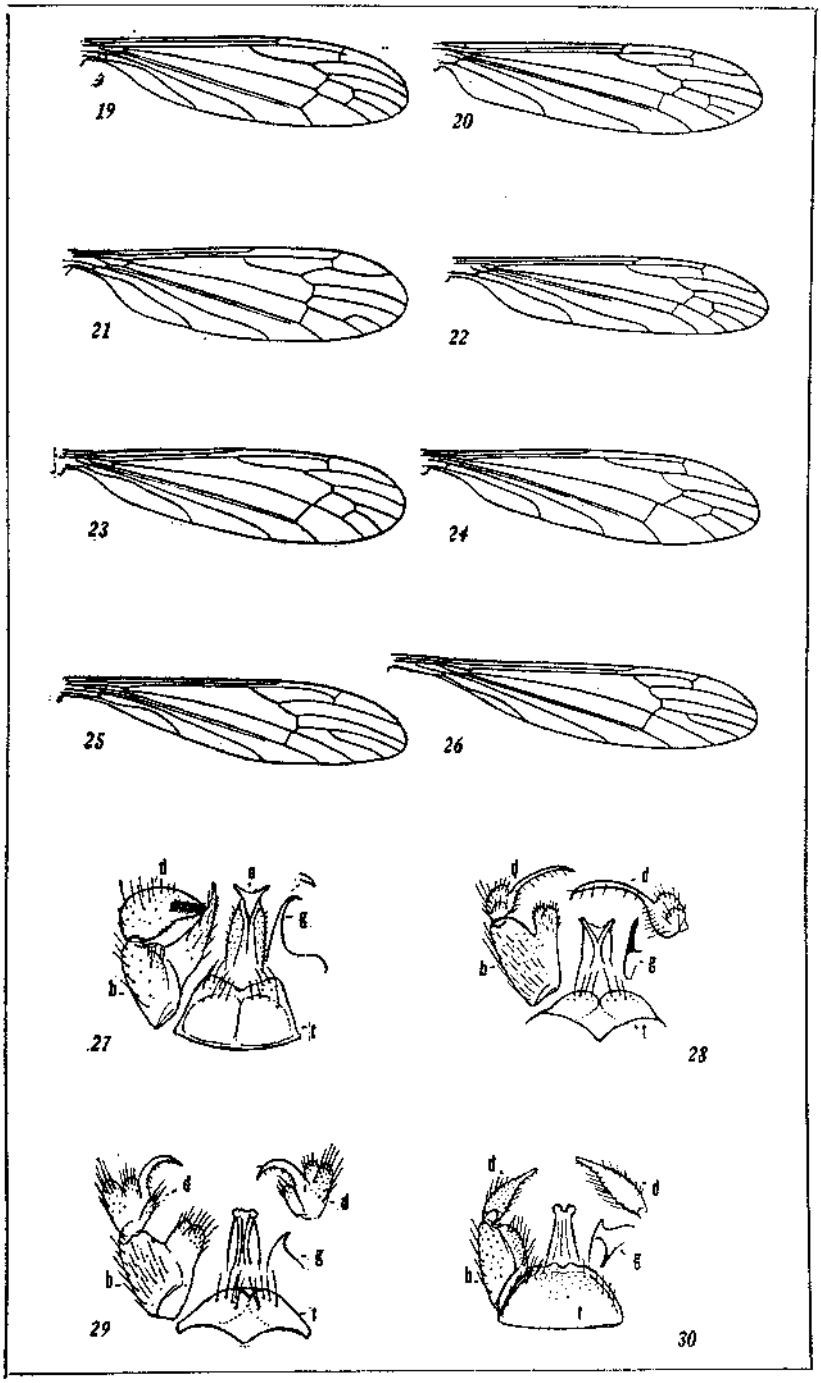



PLATE 2.

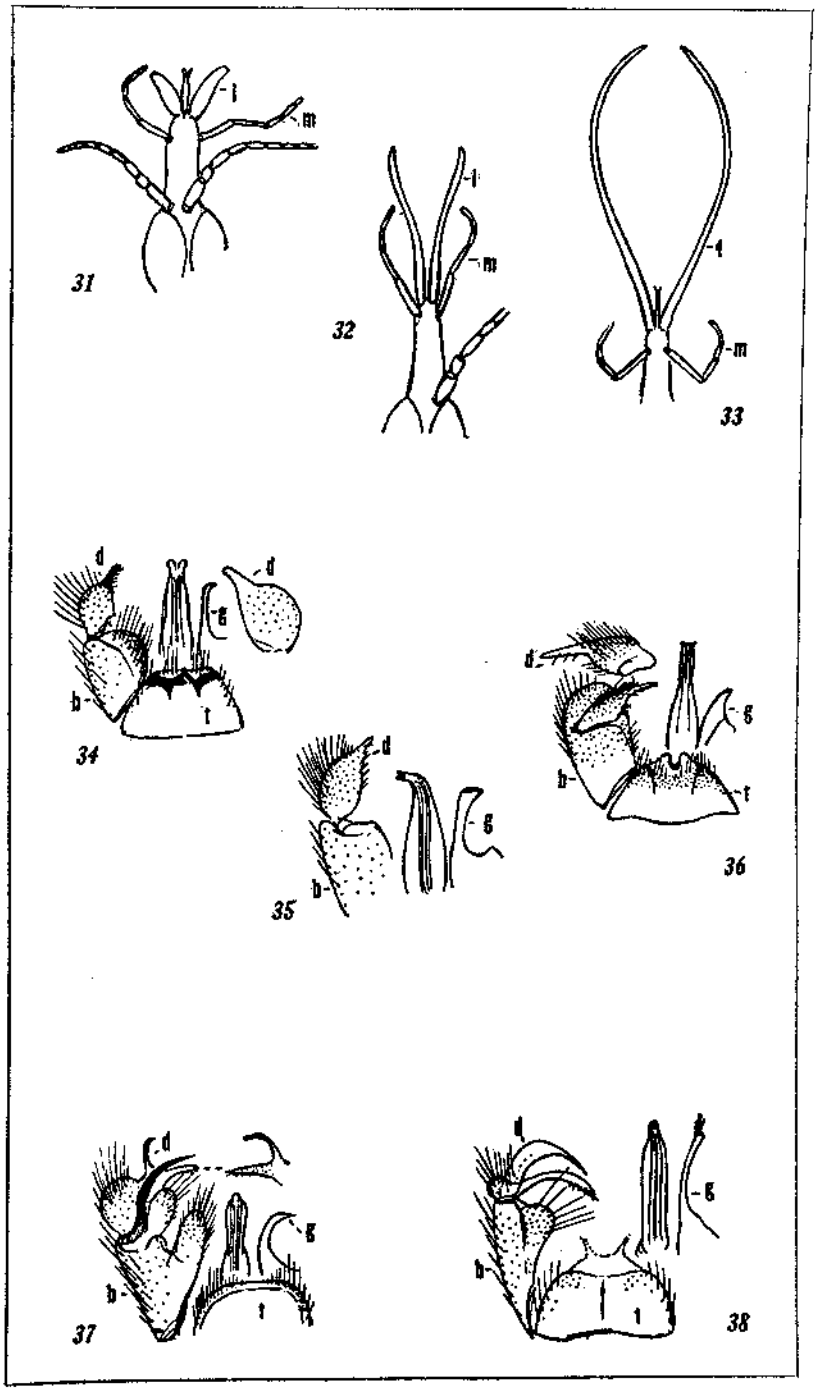



PLATE 3.

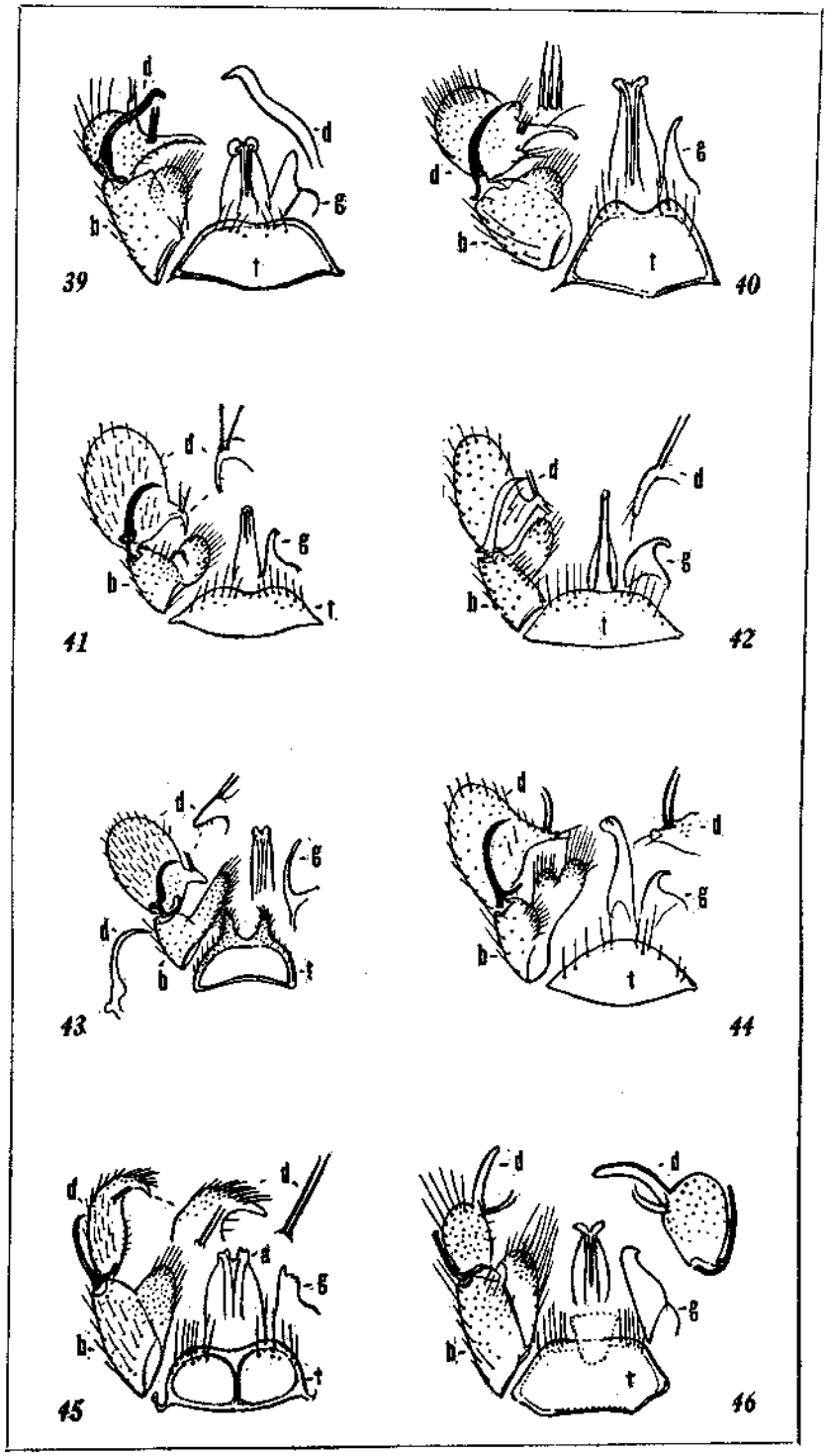

d
d
g
b
t
39
d
g
d
b
t
40
d
g
b
t
41
d
d
g
b
t
42
d
g
d
b
43
d
d
g
b
t
44
d
d
g
b
45
d
d
g
b
t
46

PLATE 4.

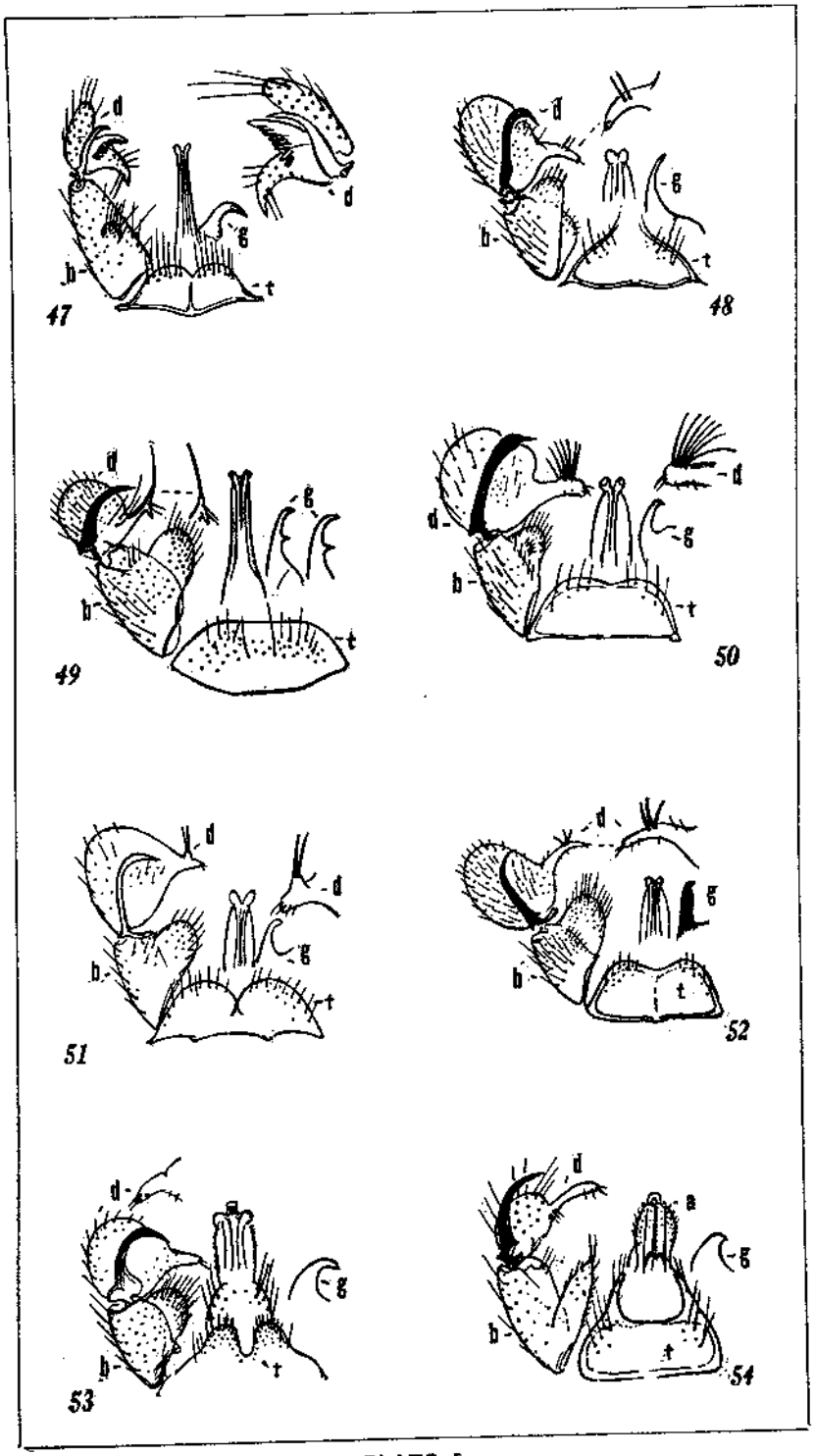

d
d
g
b
t
47
d
g
b
t
48
d
g
b
t
49
d
d
g
b
t
50
d
d
g
b
51
d
g
b
t
52
d
g
b
53
d
a
g
b
t
54

PLATE 5.

## CONTENTS


| | Page |
|---|---|
| SANTOS, SEVILLA PATROCINIO, BETTY S. LAT, and MACARIO A. PALO. The antibiotic activities of some Philippine lichens | 325 |
| PAYUMO, ESTELITA M., and PACITA L. MANIQUIS. Ascorbic acid retention in bottled fortified orange juice during processing and storage | 337 |
| ISBERTO, ANITA R., ALICIA P. BAUTISTA, CARLITA C. GERVACIO, and LEOGARDA B. DIMAUNAHAN. The effect of various cooking procedures on cooking losses and retention of B-vitamins in pork and beef | 343 |
| PALAD, JOSE GARCIA, ISABEL C. ABDON, AUREA V. LONTOC, LEOGARDA B. DIMAUNAHAN, EMERINA C. EUSEBIO, and NATIVIDAD SANTIAGO. Nutritive value of some foodstuffs processed in the Philippines | 355 |
| PASCUAL, O.S., and ZENAIDA S. GARCIA. Relative stabilities of some allylic cyclic isomers | 385 |
| PASCUAL, O.S., and E. ALMEDA. Relative stabilities of some conjugated olefins | 391 |
| JULIANO, JOSE O. The absolute determination of neutron fluxes by coincidence measurements | 399 |
| LEVITON, ALAN E. Contributions to a review of Philippine Snakes, VI. The snakes of the genus Oxyrhabdium | 407 |
| SCHEDL, KARL E. Synonymies of bark beetles, XIII. Contribution to the taxonomy of the Scolytoidea. 221 | 423 |
| ALEXANDER, CHARLES P. New or little-known Tipulidæ from eastern Asia (Diptera), LV | 427 |


## NOTE TO CONTRIBUTORS

Manuscripts intended for publication in the Philippine Journal of Science should be sent to the Editor, Philippine Journal of Science, National Institute of Science and Technology, Manila, Philippines.

The Journal will not be responsible for the loss of unsolicited manuscripts, but those received will be acknowledged and considered promptly by the Board of Editors or other competent critics. Authors will be notified of the decision reached as soon as possible.

Manuscripts on biology must be accompanied by abstracts for publication in the biological abstructs.

Manuscripts submitted should be typed on one side of white bond paper, 8½" × 11", and double-spaced throughout. One original copy and one carbon copy of manuscripts should be submitted.

Illustration should accompany manuscripts on separate sheets. Photographs should be sent unmounted, with serial number written on back to correspond with list of captions.

Fifty separates of each paper published in the Journal are furnished free to an author (in case of more than one author, this number is to be divided equally). Additional copies may be had at the author's expense if ordered at the time the manuscripts is submitted for publication.

The Philippine Journal of Science is published quarterly, the subscription rates per year being: Philippines, U. S. $5.00; Foreign, U. S. $8.00, including postage. Single issues are U. S. $1.25 in the Philippines and U. S. $2.00 in foreign countries.

Subscriptions to the Journal should be sent to the Business Manager, Philippine Journal of Science, National Institute of Science and Technology, Manila, Philippines.

Publications sent in exchange for the Journal should be addressed to the Division of Documentation, National Institute of Science and Technology, Manila, Philippines.

081610

## PUBLICATIONS AVAILABLE

CHECKLIST OF THE ANTS (HYMENOPTERA: FORMICIDÆ) OF ASIA. By J. W. Chapman and S. R. Capco. Institute of Science and Technology Monograph 1 (1951) new series. Paper, 327 pages. Price, $2.00, United States currency.

NOTES ON PHILIPPINE MOSQUITOES, XVI. GENUS TRIPTEROIDES. By F. E. Baisas and Adela Ubaldo-Pagayon. Institute of Science and Technology Monograph 2 (1952) new series. Paper, 198 pages with 23 plates and 4 text figures. Price, $2.50, United States currency.

A REVISION OF THE INDO-MALAYAN FRESH-WATER FISH GENUS RASBORA. By Martin R. Brittan. Institute of Science and Technology Monograph 3 (1953) new series. Paper, 224 pages with 3 plates and 52 text figures. Price, $2.50, United States currency.

SECURING AQUATIC PRODUCTS IN SIATON MUNICIPALITY, NEGROS ORIENTAL PROVINCE, PHILIPPINES. By Donn V. Hart. Institute of Science and Technology Monograph 4 (1956) new series. Paper, 84 pages with 22 text figures and 8 plates. Price, $1.25, United States currency.

AN ECOLOGICAL STUDY OF THE KOUPREY, NOVIBUS SAUVELI (URBAIN). By Charles H. Wharton. Institute of Science and Technology Monograph 5 (1957) new series. Paper, 111 pages with 11 plates and 16 text figures. Price, $1.25, United States currency.

FERN FLORA OF THE PHILIPPINES. By Edwin B. Copeland. Institute of Science and Technology Monograph 6, Vols. 1–3 (1958–1960) new series. Vol. 1, 191 p., Paper, Price, $1.25; Vol. 2, 193–376 p., Paper, Price, $1.75; Vol. 3, 377–577 p., Paper, Price, $1.75, United States currency.

THE PHILIPPINE PIMPLINI, PŒMENIINI, RHYSSINI, AND XORIDINI. By Clare R. Baltazar. National Institute of Science and Technology Monograph 7 (1961) new series. Paper, 120 pages with four plates. Price, $1.50, United States currency.

PACIFIC PLANT AREAS. Edited by C.G.G.J. Van Steenis. National Institute of Science and Technology Monograph 8, Vol. 1 (1963) new series. Paper, 246 pages with 26 maps. Price, $3.00, United States currency.

INDEX TO THE PHILIPPINE JOURNAL OF SCIENCE, VOL. 59 (1936) TO VOL. 79 (1950). By Angel Y. Lira. National Institute of Science and Technology Monograph 9 (1963) new series. Paper, 325 pages. Price, $3.00, United States currency.

THE ARCHAEOLOGY OF CENTRAL PHILIPPINES. By Wilhelm G. Solheim, II. National Institute of Science and Technology Monograhp 10 (1964) new series. Paper, 235 pages with 29 text figures and 50 plates. Price, $3.00, United States currency.

031610